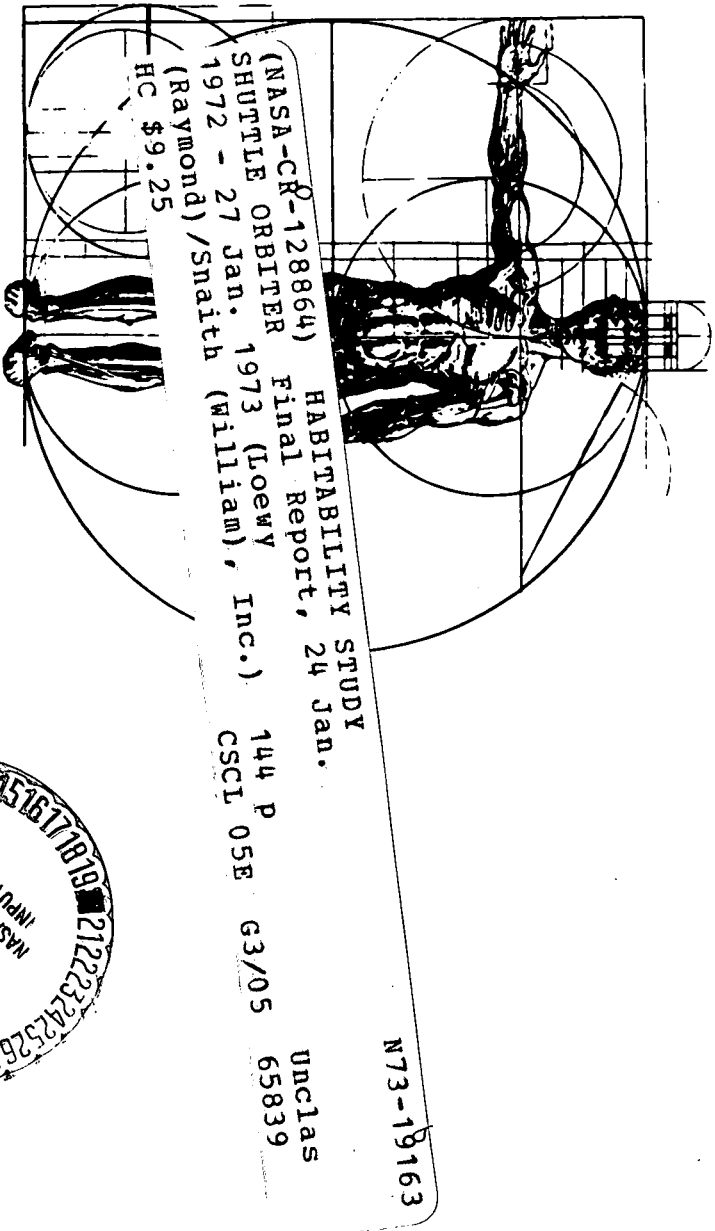


# FINAL REPORT

MS 9-12479

QR-128864



# HABITABILITY STUDY SHUTTLE ORBITER

JANUARY 1972/DECEMBER 1972

PREPARED FOR **NASA** BY  
RAYMOND LOEWY/WILLIAM SNAITH, INC.  
110 EAST 59 STREET, NEW YORK, N.Y. 10022



Dealing of illustrations in this document may be better studied on microfiche

## FOREWORD

This report covers work accomplished by Raymond Loewy/William Snaith, Inc. for the Manned Spacecraft Center, Houston, Texas, from January 24, 1972 to January 27, 1973.

As a consultant design office, we have provided habitability design services for the Shuttle Orbiter Program as requested by MSC. It was our goal to quickly provide NASA with a variety of creative solutions for the stated tasks. Sketches, mock-ups, mechanicals and models were the mediums used to communicate our ideas and to establish a foundation for future development.

## TABLE OF CONTENTS

<b>FOREWORD</b>	<b><u>Page</u></b>
<b>TABLE OF CONTENTS</b>	<b>i</b>
SECTION A - Shuttle Orbiter Crew Compartment/X-Axis Docking	ii
SECTION B - Shuttle Orbiter Passenger Compartment/Flight Deck	1
SECTION C - Restraint System for Hygiene Facility (Phase I)	10
SECTION D - Small Passenger Couch	23
SECTION E - Food System and Galley	40
SECTION F - Temporary Restraints	50
SECTION G - Restraint System for Hygiene Facility (Phase II)	65
SECTION H - Skewed Z-Axis Dock/Airlock System Shuttle Orbiter - 1/20 Scale Model	72
SECTION I - Positive Flexible Restraints (Phase I)	84
SECTION J - Positive Flexible Restraints (Phase II)	90
SECTION K - Shuttle Orbiter Passenger Couch - Full Scale Model	99
SECTION L - Data Format Card	104
SECTION M - Housekeeping Equipment Stowage	109
SECTION N - Shuttle Orbiter Storage Locker System	114
	125

SECTION  
A

TASK Shuttle Orbiter Crew Compartment/X-Axis Docking

CENTER MSC - Allen J. Louviere

DATE ASSIGNED 3 January 1972

PARAMETERS

- 1 Consider operation in 3 modes of orientation - launch, Zero-G, re-entry.
- 2 6-man crew -maximum of 4 crewmen occupy crew compartment at launch.
- 3 Crew compartment consisting of a 94"H X 108"W X 196"L module.
- 4 Immediate access necessary to emergency escape hatch and head during launch.
- 5 A 39" passage through the crew compartment extending from the airlock to the rear bulkhead.

TASK OBJECTIVES

To develop a working crew compartment configuration which satisfies the operational requirements for launch, Zero-G and re-entry modes.

SCHEDULE

Following the task assignment, a meeting was scheduled for January 12, 1972.

ANALYSIS OF  
EXISTING CONCEPT  
FIGURE A1

Generally, Raymond Loewy/William Snaith, Inc. felt that the Shuttle Orbiter 040A Crew compartment/X-Axis docking failed to coordinate the launch, Zero-G, re-entry orientation modes into well defined activity areas. Specific criticism included:

- 1 Launch entrance to the Hygiene Compartment is difficult. Extreme body maneuvering is required to gain entrance.
- 2 The systems engineer has no visual contact with the pilots.
- 3 Access to the emergency escape hatch is awkward. Unnecessary maneuvering is required to reach exit platform.
- 4 Chairs 5 and 6 store for launch which require undue preflight and flight adjustments.
- 5 Mobility through the craft is very limited in all flight modes. A specific passageway should be established to organize flow through the vehicle.
- 6 Avionics is dispersed throughout the vehicle. A more integrated plan is needed.

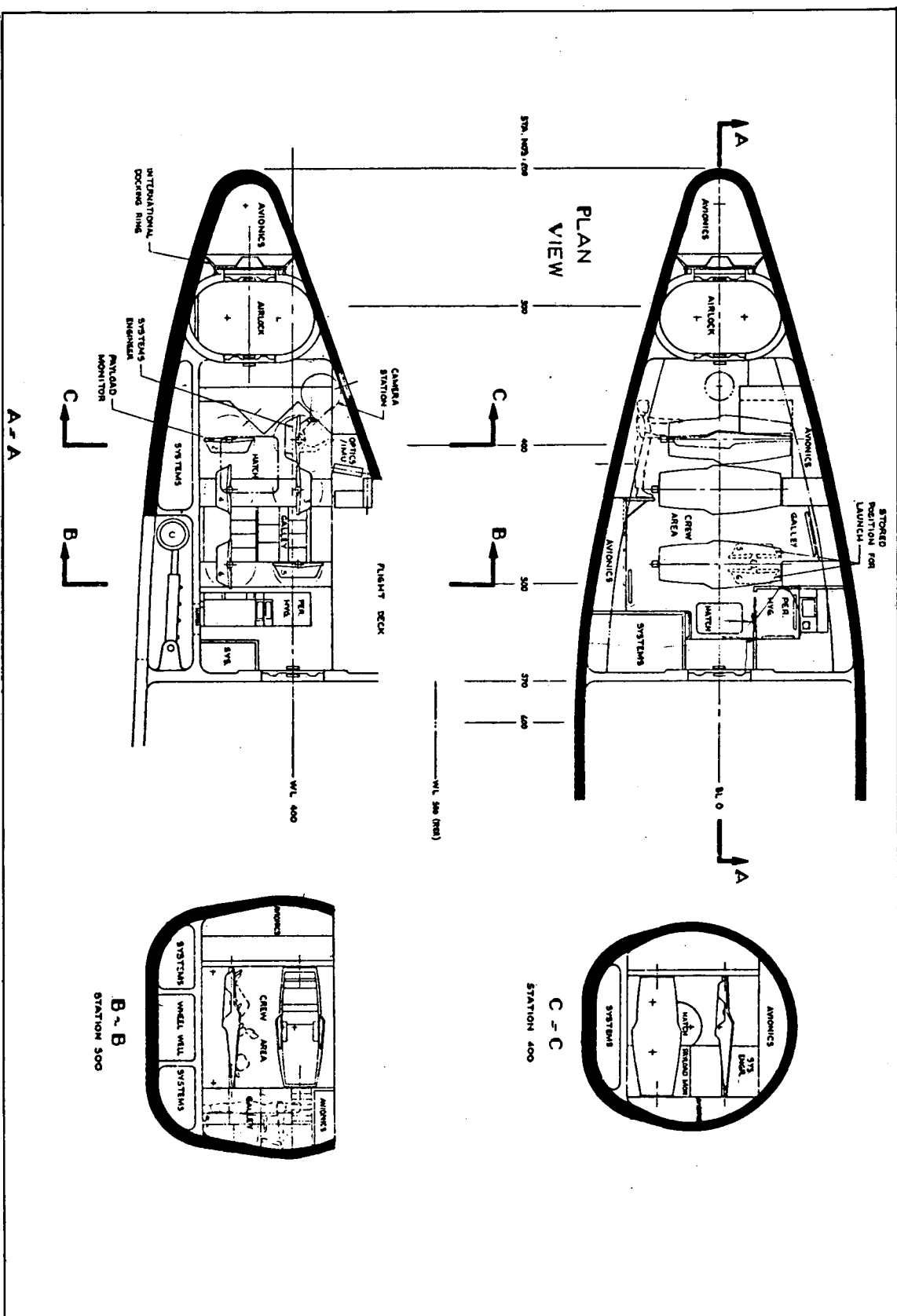
## LOEWY/SNAITH APPROACH FIGURES A2 AND A3

### 1 Crew Compartment Description

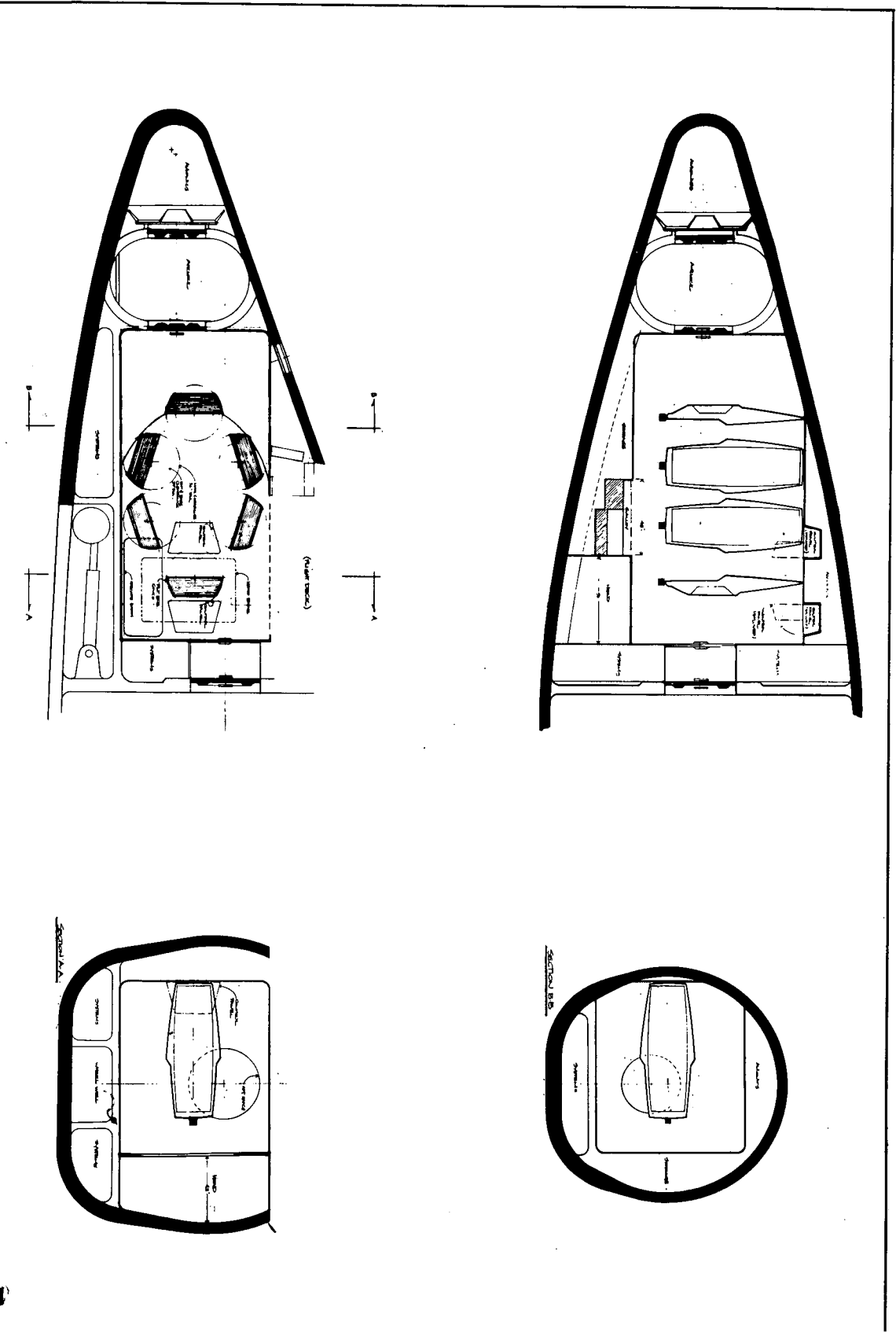
Emphasis was placed on the accessibility of the emergency escape routes during launch and availability of the Hygiene Compartment to individual crew couches. An aisle was established to define routes of travel and outline activity areas. In the Crew Compartment (Figure A4), the head and galley are along a common wall with a 20" passageway between the wall position and the structural supports of the space couch.

#### a Advantages

- (1) The crew compartment has been reorganized to socially orient the space couches to allow the entire crew to have visual contact with each other. The couches can be tilted to suit individual preferences.



A1 - MSC Shuttle Orbiter Crew Compartment/X-Axis Docking



A2 - Loewy/Snaith Crew Compartment Configuration



- (2) The system's control panels have been integrated to allow one systems engineer to operate all controls. The engineer's couch has been positioned to enable him to have visual contact with the pilots.
- (3) The escape hatch has been placed adjacent to the rear bulkhead. An aisle at the tail end of their couches provides a quick drop down to the rear bulkhead and a few steps to the outer skin.
- (4) Easy accessibility to the head has been provided via an aisle and the couch supports which double as mobility aids to the crewmen.
- (5) The avionics have been integrated in the area of the rear bulkhead. A depth of 24" is required to house the adequate volume.

b Disadvantages

- (1) A 39" passage, extending from the airlock to the rear bulkhead has been restricted by placing the two end couches in a social configuration, centered between the four couches positioned near the outside spacecraft walls. The obstruction can be alleviated, however, by shifting the two extreme space couches along their structural support rails to a position near the floor or ceiling, creating maneuverability room for the entire length.
- (2) The space couch support poles tend to overpower the compartment and interfere with some free passageway movement.

Galley Compartment Description (Figure A5)

The galley provides minimal storage and work area with modular interchangeable compartments. Located adjacent to the head, it is positioned on a wall opposite that of the escape hatch. The area has been designated to accommodate 6 men for 7 days, operated by either one galley attendant or each crewman.



a Advantages

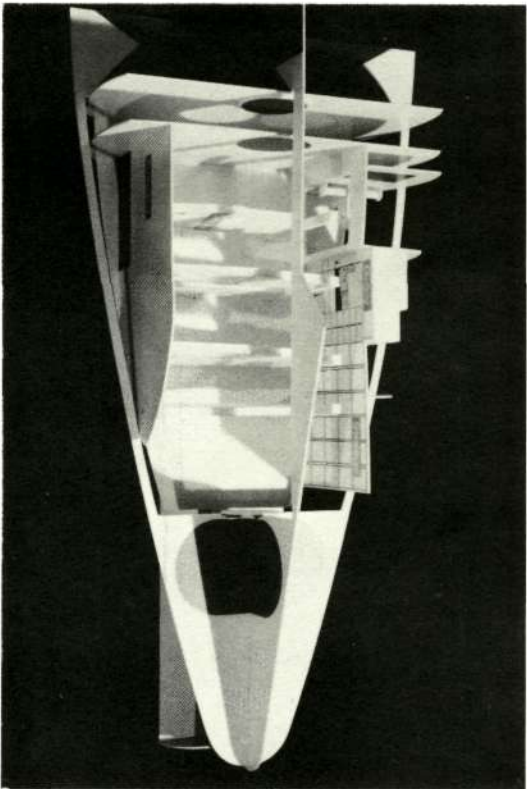
- (1) The galley location is in an area readily accessible to the space couches.
- (2) It contains all stores, food preparation devices, food service implements, as well as housekeeping stowage in a minimum sized area.
- (3) Standard Skylab food cans utilized.
- (4) Two options for heating food are provided:
  - (a) Individual space couch food preparation (food tray jacked into individual's couch to heat food).
  - (b) Food may be prepared at galley unit.

b Disadvantages

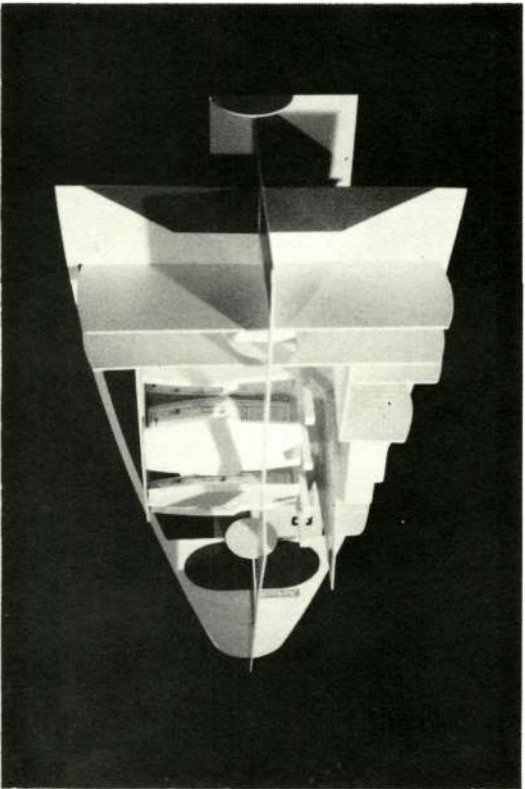
- (1) Galley attendant obstructs passage while preparing food.
- (2) Limited room for maneuverability (conflict with space couches from rear).
- (3) Possibility of meal selection is somewhat limited due to storage capacity and preparation area.

3 Hygiene Compartment Description (Figures A6 and A7)

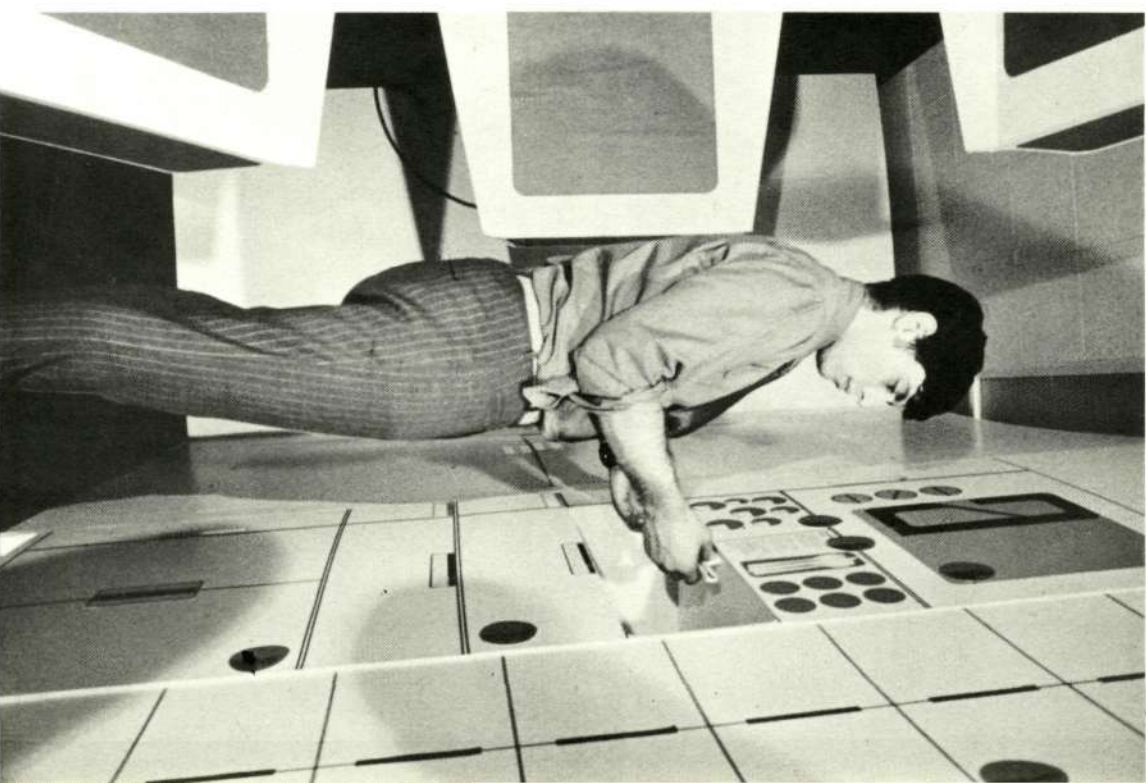
Located opposite the emergency escape hatch and adjacent to the galley, the Hygiene Compartment has been positioned for easy access in all modes or orientation. Special attention has been paid to maneuvering into this facility during pre-launch hold periods (Figure A8). The orientation of the craft requires maneuvering down the walls of the craft to gain access from the rear bulkhead position. A gimble collector unit enables



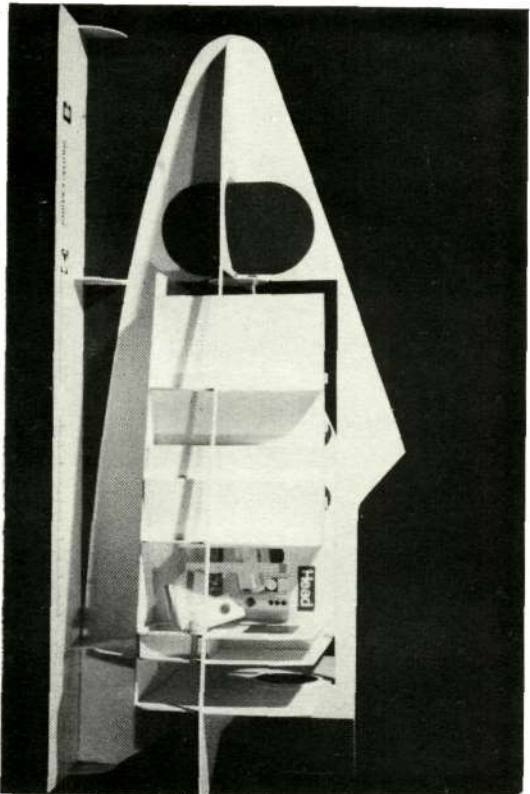
A3 - Loewy/Snaith Shuttle Orbiter Model in the Launch Orientation



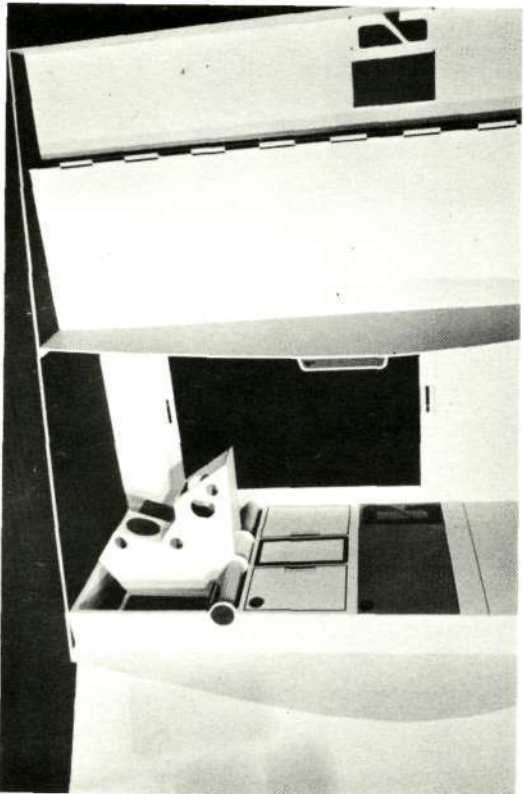
A4 - Loewy/Snaith Shuttle Orbiter Model in a Leisure Orientation



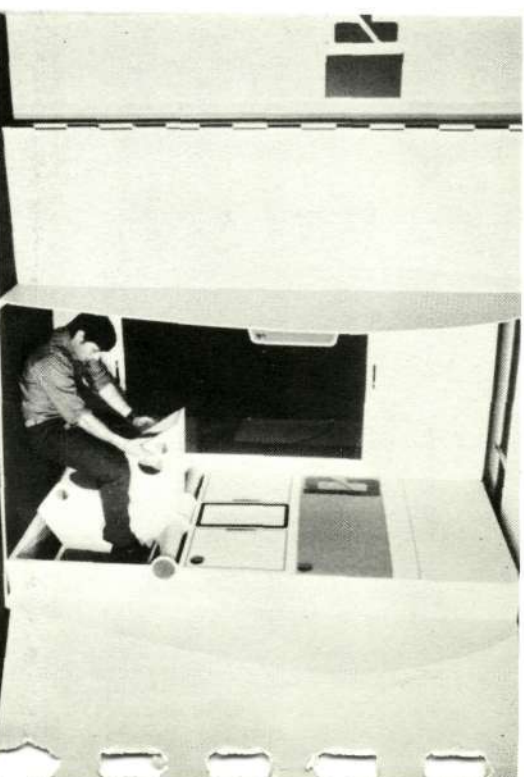
A5 - Full Size Mock-Up of Food Management Compartment



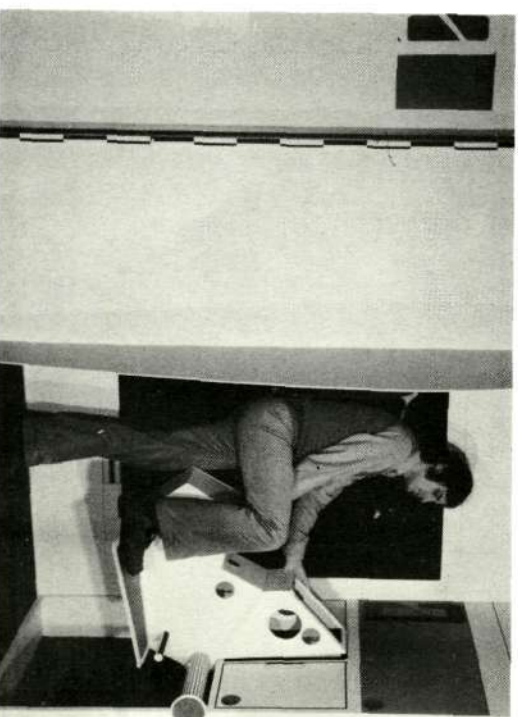
A6 - Loewy/Snaith Shuttle Orbiter Model Illustrating the Hygiene Collector Unit in a "I-G" or "O-G" Mode



A7 - Full Size Mock-Up of Hygiene Compartment



A8 - Full Size Mock-up of Hygiene Compartment in Launch Orientation



A9 - Hygiene Compartment Fecal/Urinal Collector Mock-Up in "I-G" Re-Entry Orientation

the fecal collector to be used in all phases of orientation including inter atmosphere 1-G Flight (Figure A9). This was accomplished by pivoting the collector around an axis to satisfy requirements in all attitudes. The handwash unit, fastened directly above, shifts into the various modes as does the fecal/urinal collector. All services to these units interface with the walls through the center of the pivot.

a Advantages

- (1) Fecal collector and hand wash unit adaptable to 3 orientations (launch, 1-G Flight, Zero-G).
- (2) Units limited to one wall (modular replacement).
- (3) Hygiene tambour doors enable two opposite stabilizing motions convenient to the 3 orientations.

b Disadvantages

- (1) Trousers must be removed to urinate/defecate.
- (2) Must sit down to use hand wash and to urinate in re-entry.
- (3) Difficult collector maneuverability in head for different orientations.

SECTION  
B

TASK Shuttle Orbiter Passenger Compartment/Flight Deck

CENTER MSC - Allen J. Louviere

DATE ASSIGNED 13 January 1972

## PARAMETERS

- 1 Operational in three modes of orientation: launch, leisure/sleep, re-entry.
- 2 6-man crew.
- 3 Orbiter passenger compartment size limited to 90"H X 108"W X 196"L.
- 4 Access to head and escape hatch during launch.
- 5 Consideration in design for maneuverability of elderly and women.

## TASK OBJECTIVES

To explore possible solutions to the problems of access to the space couch in its various orientations.

## SCHEDULE

A final presentation was scheduled for February 9, 1972.

ANALYSIS OF  
EXISTING CONCEPT

None.

LOEWY/SNAITH  
APPROACH

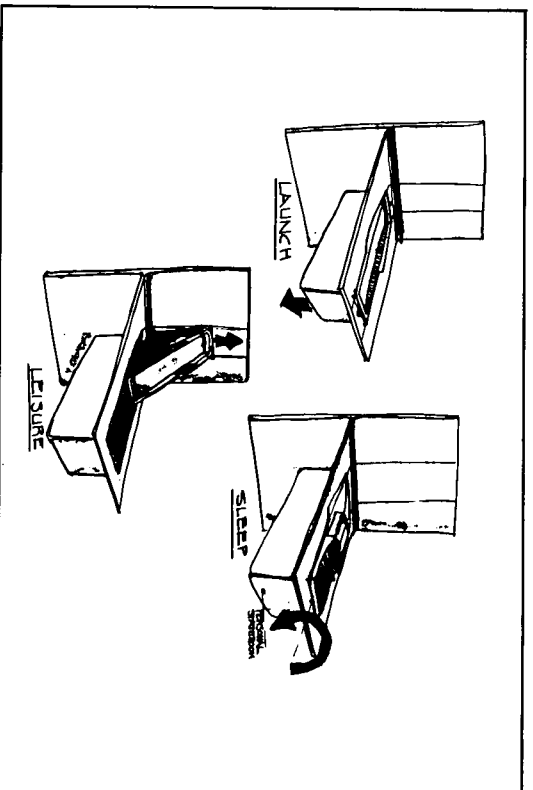
In this study of the Shuttle Orbiter Passenger Compartment, Raymond Loewy/William Snaith, Inc. was interested primarily in exploring solutions to the problems of "mounting and dismounting" the space couch in its various orientations. The primary modes of orientation within the Shuttle Orbiter include:

- 1 Launch - Under the effects of 1-G the passengers on the launch pad should have immediate access to all space couches, the hygiene compartment and the escape hatch(es).
- 2 Leisure/Sleep - In Zero-G flight all areas of the passenger compartment should be accessible including the hygiene compartment, the food management unit, the airlock and related facilities.
- 3 1-G Horizontal Flight - The head should be available.

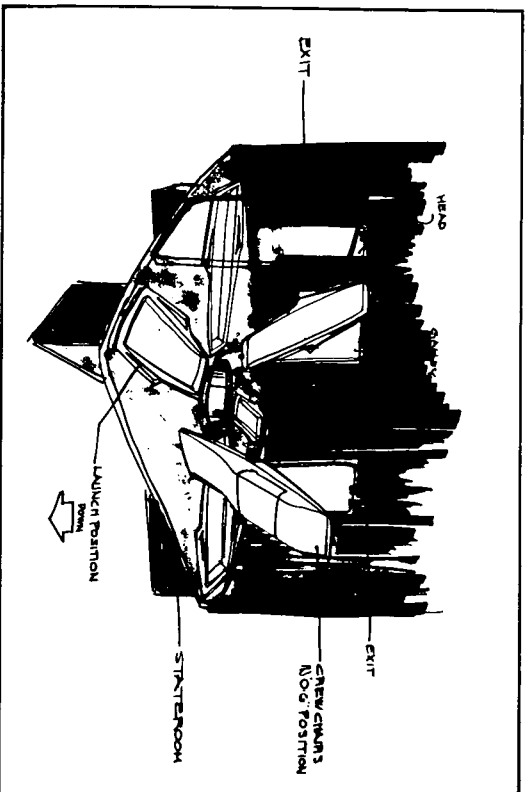
With the knowledge that future space flight may include the elderly, it was important to consider less strenuous techniques of maneuverability throughout the passenger compartment, especially during pre-flight and 1-G flight.

Satisfying launch, leisure/sleep and re-entry orientation of the space couch and providing accessibility to the equipment necessary during each of these modes were the prime objectives of this effort. The interface of these facilities within other shuttle orbiter hardware and systems was not a primary concern in this phase to avoid deterring any innovative ideas.

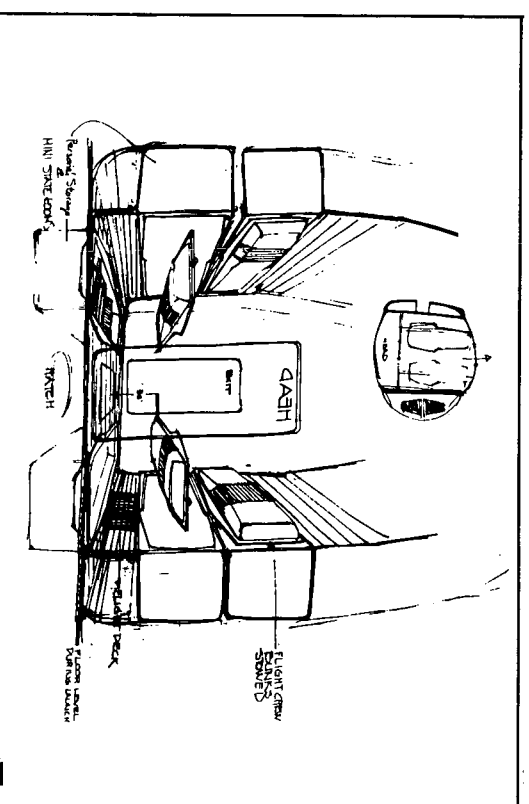




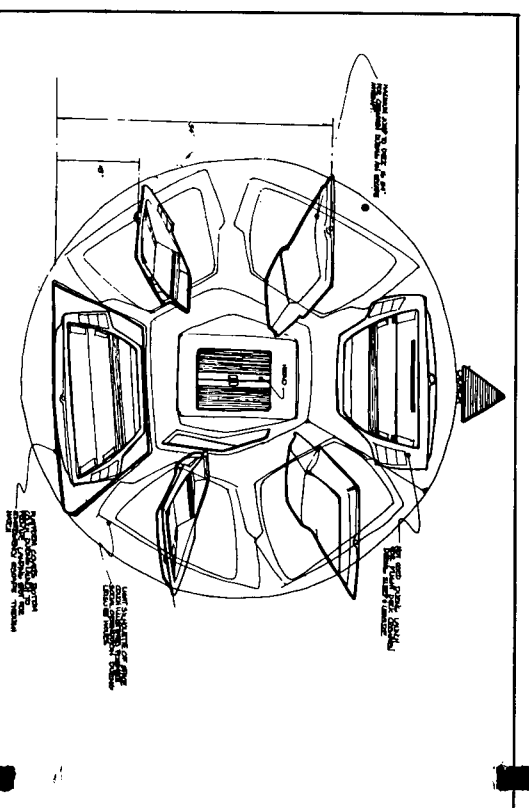
B1 - Compartment Modularization in the Three Couch Orientation Modes



B2 - Compartment Configuration



B3 - Space Couch in Bracket-Supported Modular Compartment



B4 - Space Couches Positioned Horizontally

## APPROACH A

## Modular Compartment Environmental Systems.

1

Description

With the possibility of frequent "on pad" servicing, it became evident that modularization of components would be a procedure worth pursuing. Cubicles, including couch, storage and services, interchangeable on earth would enable the passenger compartment to be completely refurbished quickly between missions. Within these modules, the space couches would articulate for easy access.

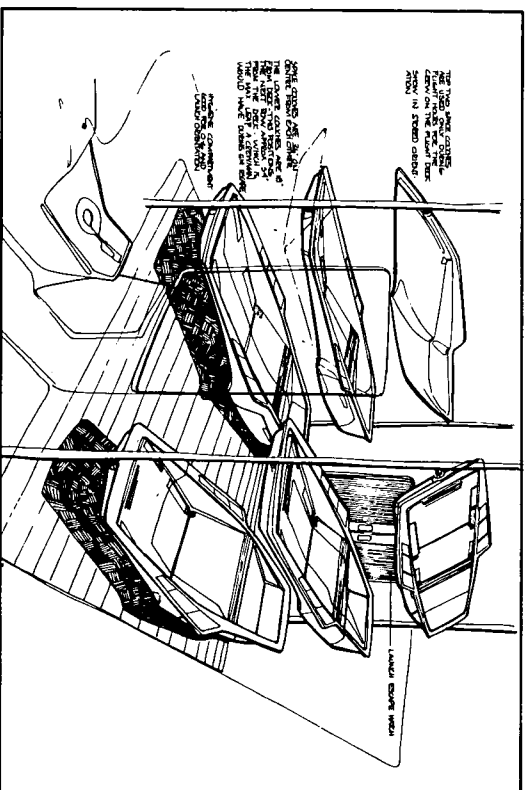
Figure B1 illustrates an example of modularization in the three couch orientation modes. The leisure mode demonstrates the gimble procedure the couch performs to enable easy mounting, escape and hygiene facility access. The compartment configuration shown in Figure B2 utilizes these modular units. The diagonal couches shown are for the flight deck crew to use in Zero-G only.

Figure B3 is another modular example of the flexibility provided. The brackets supporting the space couches allow the crewman to raise or lower them in order to increase its mounting and dismounting accessibility.

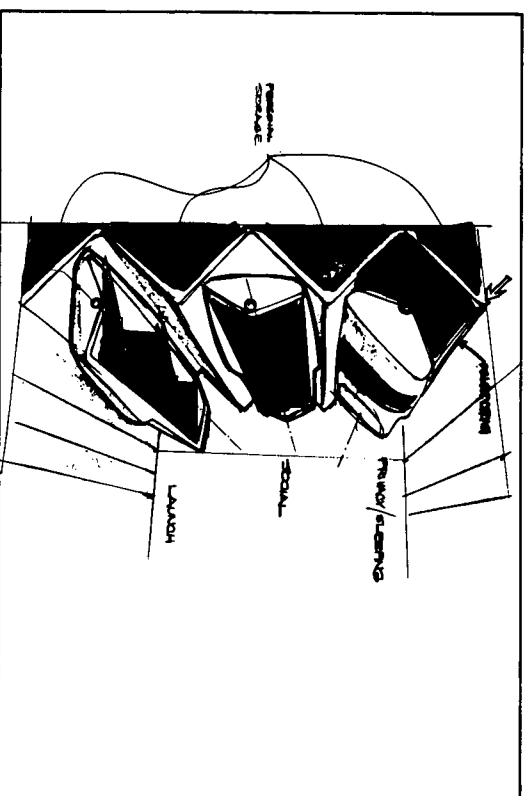
As illustrated in Figures B4 and B5, the couches used in launch are positioned horizontally making the maximum height necessary to negotiate into, 54" above the deck. This alleviates the problems of manipulating procedures necessary in obtaining access to the space couches.

Figures B6 and B7 demonstrate the diversification possible in the arrangements of modular couches. The configurations enable the spacecraft sides to be utilized as partitions to create semi-private quarters during sleep and provide areas for temporary clothing storage.

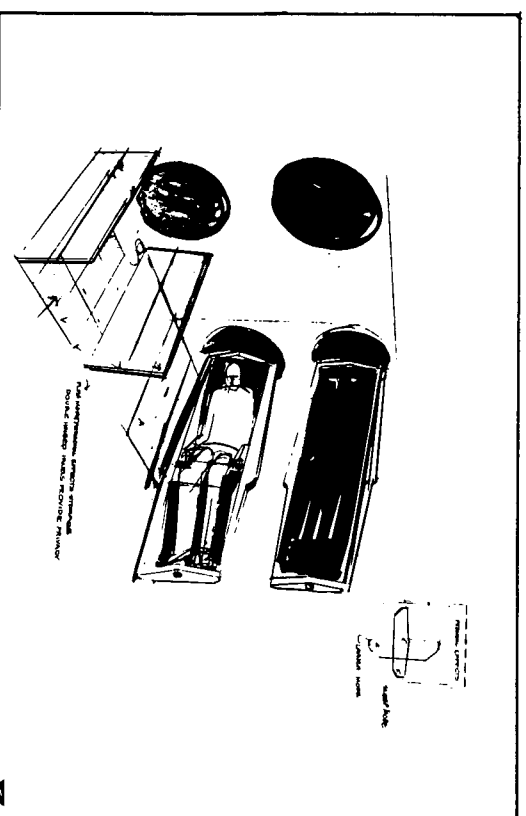




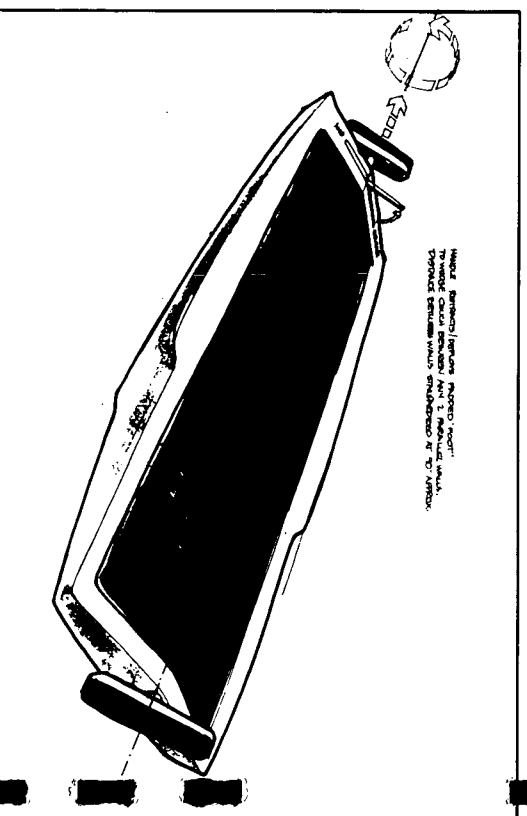
B5 - Horizontally Mounted Adjustable Couches



B6 - Couches Utilizing Partitions to Create Semi-Private Quarters



B7 - Space Couch Utilizing Overnight Clothing Unit as Privacy Screen



B8 - Adjustable Couch Held in Place by Spring Tension Posts

Figure B8 provides extreme flexibility in compartment configurations because of its maneuverability ease. Positioned permanently during launch in the correct orientation, it can be readjusted via spring post ends covered with a spongy material repositioned elsewhere.

## 2

### Advantages

- a Servicing is easy and parts are interchangeable.
- b Couch and sleep compartment designed as one component.
- c Privacy is provided.
- d Easy access to couches.
- e Privacy screen provided by available storage unit doors (Figures B6 and B7).
- f Flexibility of couch positions (Figure B8).
- g Central aisle provides efficient traffic pattern.

## 3

### Disadvantages

- a Limited mobility and variation in layout (Figures B1-B3).
- b Self-contained sleep compartment concepts exhibit tendency toward a claustrophobic feeling.

## APPROACH B

Tracked Compartment Environmental System (Figures B9-B12).

# 1 Description

The parallel track creates a flexible system which allows adjustments in mission layouts. The far sides of the tracks include area for services, i.e., hygiene, galley facility, and work stations. Area between them is utilized for crew maneuvering area, as well as space couch orientations. Fixed permanently at launch, the couches are able to be readjusted along the tracks for Zero-G activities. All services to the couch interface through the tracks, to jacks mounted at intervals. A completely open space is possible by shifting all the couches to one end of the orbiter, exposing one continuous area useful for experiments and leisure activities.

## 2 Advantages

- a Modulars easy to remove for servicing.
- b Removable panels enable in-flight environmental changes.
- c Tracks allow easy "stacking of couches" to create an open space.

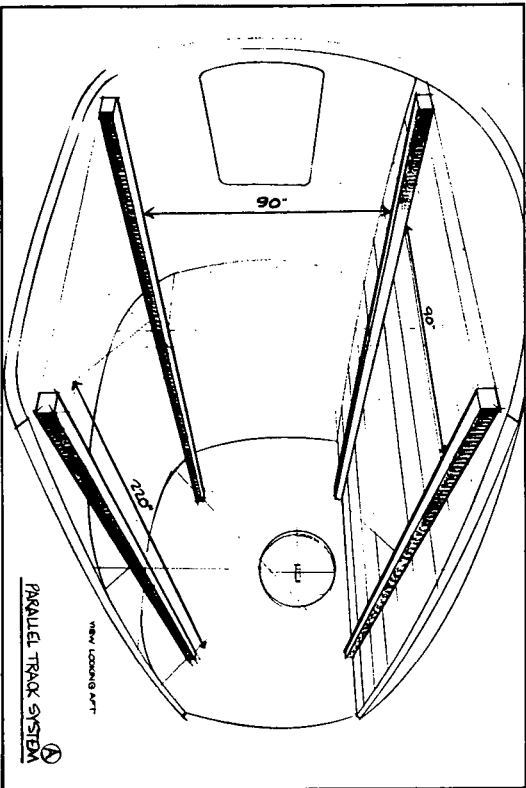
## 3 Disadvantages

- a Problems of permanently affixing units to withstand launch "G" loads.
- b Excess room is necessary to accommodate interchangeability of facilities.

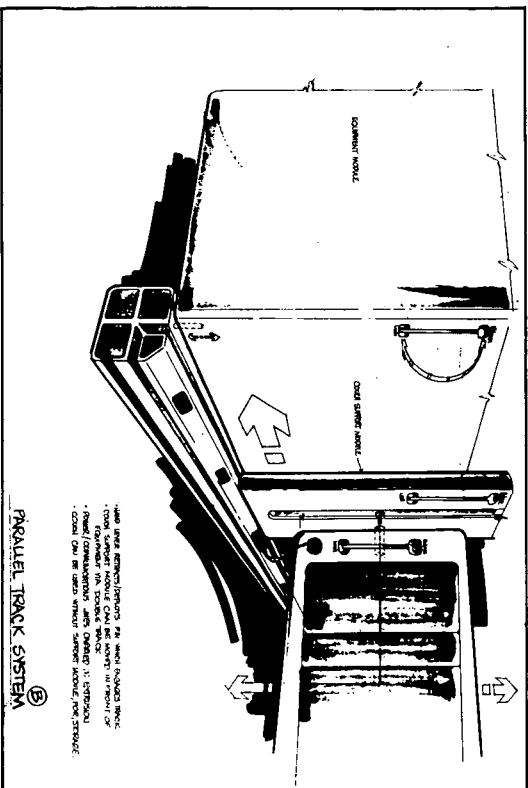
## APPROACH C Articulated Space Couch Utilization.

# 1 Description

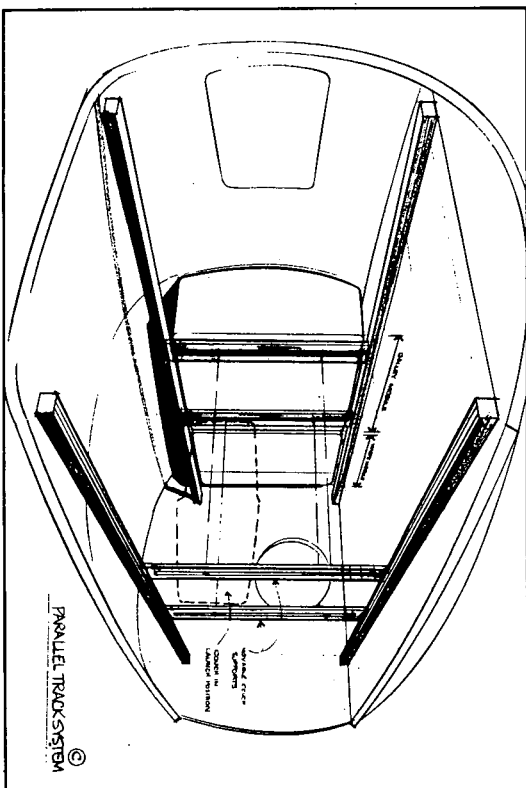
To increase accessibility to the space couches in the various modes of orientation, articulations have been incorporated. These maneuvers create adjustments which



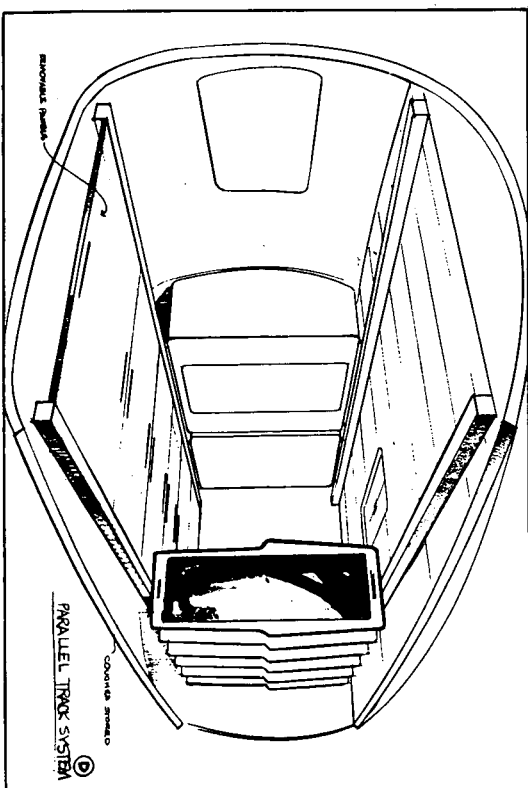
B9 - Tracked Compartment Environmental System



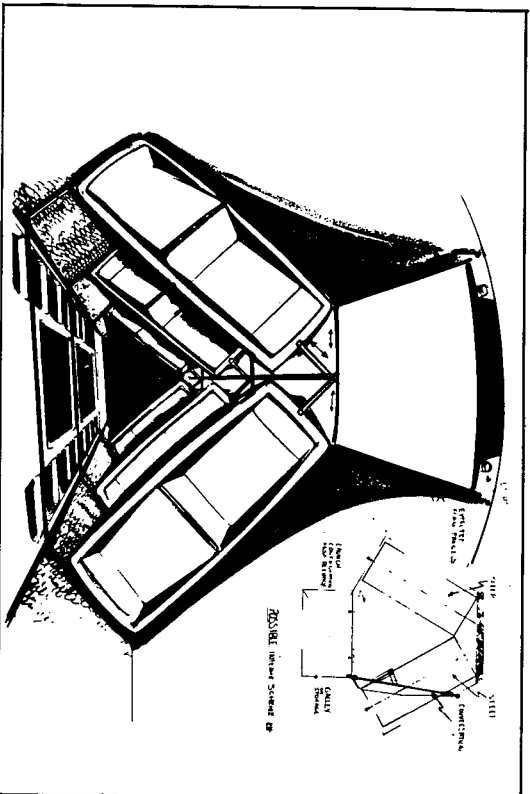
B10 - Space Couch and Track Detail



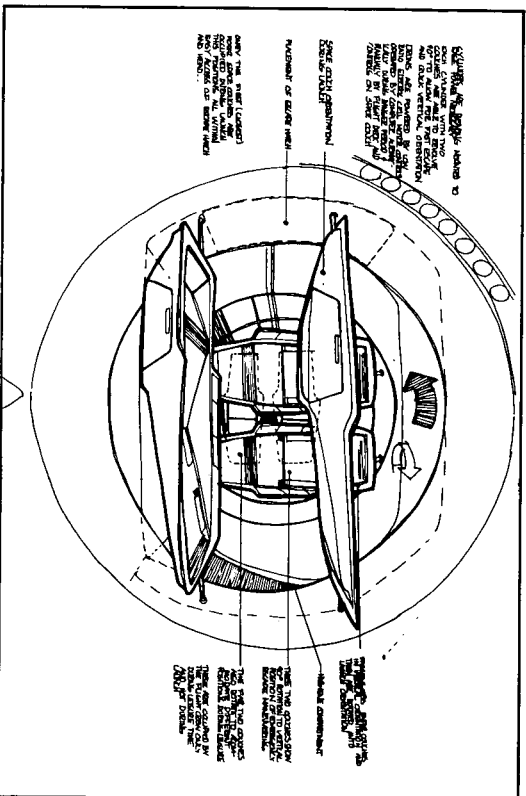
B11 - Service Modules and Couch Support Concept



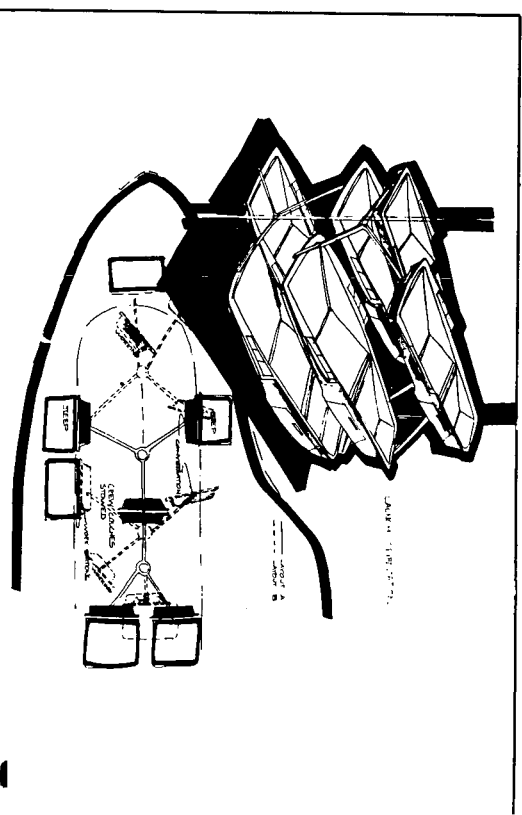
B12 - Environmental Variations



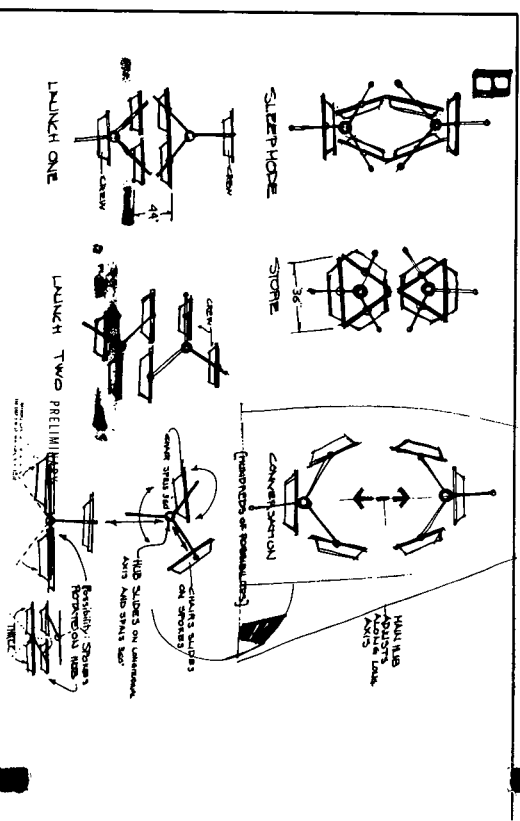
B13 - Space Couch Manipulation for Convenient Access



B14 - Revolving Cylinders for Easy Access



B15 - Space Couch on Spoked Hubs for Free Repositioning



B16 - Multiple Configurations

increase the amount of compartment configurations variations, as well as maintaining mountability ease.

Figure BI3 demonstrates the manipulations the space couches are capable of to achieve their functions in various orientations. Illustrated in a position convenient for access, they pivot inboard and via tracks, can be maneuvered parallel to a configuration where the couches face each other.

Figure BI4 illustrates two revolving cylinders, each with two couches. Passengers mount and dismount the couches in their vertical orientation and then are rotated horizontal to launch orientation. Access to the hygiene compartment and escape hatch during launch is also accomplished in this manner.

Figures BI5 and BI6 expose the possibility of countless configurations. Mobilized by a floor and ceiling track, two, three spoked hubs are able to be freely repositioned. The end of each spoke acts as an axis of rotation for each of the six couches. Only the lower four are used during launch. The hubs are free to rotate and pivot allowing each to encounter diversified configurations. This layout enables several couches to be used for leisure activities without interfering with others during work station monitoring.

## 2

### Advantages

- a Increase 1-G accessibility.
- b May be arranged to create a continuous 39" clear area extending the interior orbiter length.
- c Flexibility of compartment configurations.

3

Disadvantages

- a Extremely mechanical.
- b Positioning of individual couch is dependent on location of others.
- c Large compartment usable area is necessary to accommodate these configurations.

## APPROACH D

## Flight Deck Configurations.

1

Description

In looking at the flight deck, Raymond Loewy/William Snaith, Inc. was primarily concerned with separating the leisure/sleep activities area in the passenger compartment from the operational stations, yet not inhibit audio-visual communications necessary between the pilot and systems engineer located in the passenger compartment. Since the systems engineer's station was to be used mainly for flight operations and control monitoring, we investigated the possibilities of reconfiguring it to accommodate restraints for the sleep mode of operation. This approach would result in a more efficient use of space and provide for instant access to monitoring equipment at all times. Figure B17 illustrates the use of the flight crew seat pad unfastened and repositioned behind the seat as a sleep restraint. This alleviates unnecessary travel to the passenger compartment for this activity. Utility of space was emphasized and considerations were made not to obstruct activities which were occurring concurrently. The extend of audio-visual communication between the flight deck and passenger compartment is illustrated in Figure B18. A relatively open scheme by "floating" the central deck creates passage access on both sides of the spacecraft. It visually extends one area into the next, it enables partial visual communications and adequate maneuvering area to translate from the flight deck to the passenger compartment, yet allows for individual compartment identity.

2

2

Advantages

- a Inter-compartment audio-visual communications provided.
- b Sleep restraint available for flight deck use.
- c Open deck concept gives the feeling of spaciousness.
- d Maximum accessibility to spacecraft compartments from flight deck.

3

Disadvantages

- a Conflicting activity areas.



## B18 - Flight Deck Crew and Area Configuration

SECTION  
C

## TASK

Restraint System for Hygiene Facility (Phase I).

## CENTER

MSC - Gordon Rysavy

## DATE ASSIGNED

14 February 1972

## PARAMETERS

- 1 Hygiene compartment to be operational in three attitudes:
  - a Launch - Axis of orbiter perpendicular to horizon.
  - b Zero-G.
  - c In atmosphere flight - Axis of orbiter parallel to horizon.
- 2 Accommodate male and female personnel.
- 3 5th to 95th percentile personnel sizes.
- 4 Fecal/urinal collector used in launch, Zero-G.
- 5 In 1-G Flight, crewman may use the standing urination facility only.
- 6 Interior volume to approach 30" X 30" X 78".

## TASK OBJECTIVES

In order to fully evaluate the task of restraint systems, Raymond Loewy/William Snaith, Inc. considered it important to analyze the entire hygiene facility according to its functions and operational needs including the fecal/urinal collector, handwash unit, oral and body wash unit.

## SCHEDULE

A final presentation of this task was scheduled for 4 April, 1972, with an intermediate preliminary review held in March to discuss concepts developed to date.

## ANALYSIS OF EXISTING CONCEPT

The existing MSC Houston Shuttle Orbiter Personal Hygiene Facility (Figure C1) represented a baseline for this task; the systems contained a fecal/urinal collector and personal hygiene unit. The units were designed as quick disconnect modules to facilitate "off-the-pad" refurbishing, "on-pad" checkouts and space flight repairs if required.

The existing system falls short in certain areas of compatibility with 5% to 95% male and female crewmen. An example of this problem is illustrated in Figure C1. The lack of head room in the seated fecal position (Zero-G) dictates its use in an awkward body orientation not conducive to easy waste elimination. Use of the handwash unit while seated on the fecal/urinal collector is restrictive in the launch mode.

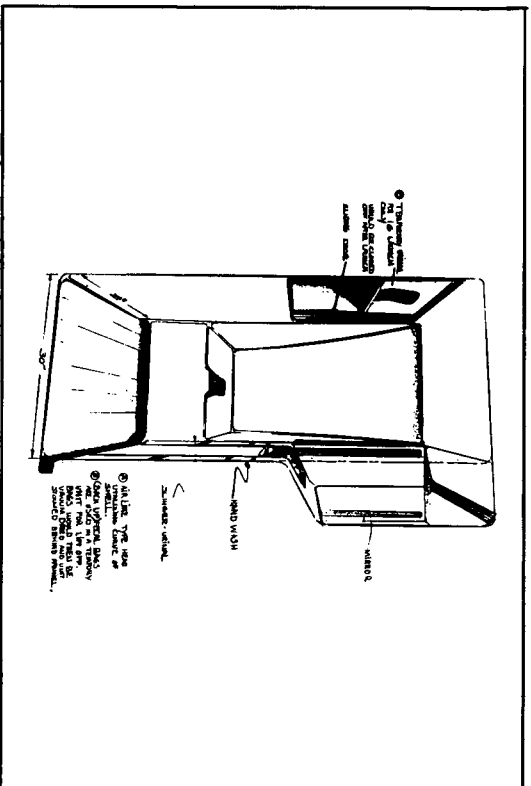
## PRELIMINARY ARRANGEMENT STUDIES

The preliminary studies of the hygiene facility conducted were aimed at minimizing the volumetric requirements of the hygienic facility and developing appropriate restraint concepts.

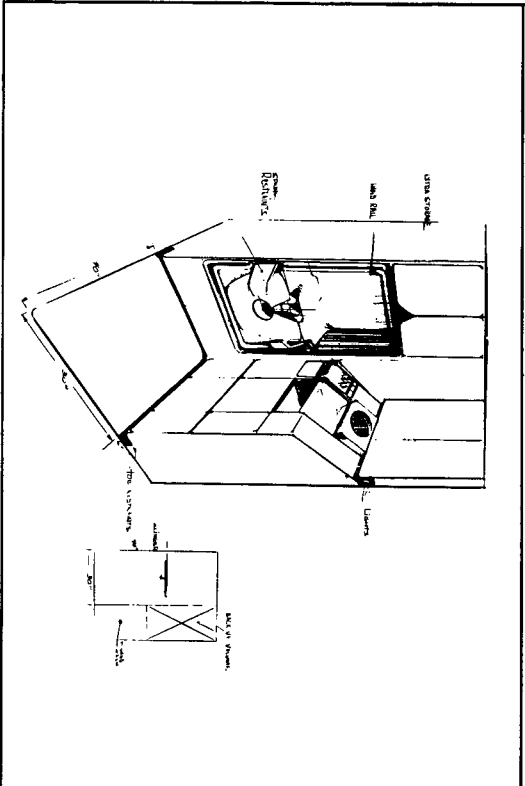
Figure C2 illustrates an airline version of a hygiene facility. Back-up fecal bags would be used for defecation prior to lift off (upper left wall). The cavity above the handwash unit provides head clearance if defecation is required prior to launch.

Figure C3 positions the handwash unit and fecal/urinal collector on adjacent walls. The area in between accommodates back-up volume. This volume would normally utilize space opposite the collector unit. An interior area of 40" X 30" is necessary to allow enough head clearance.

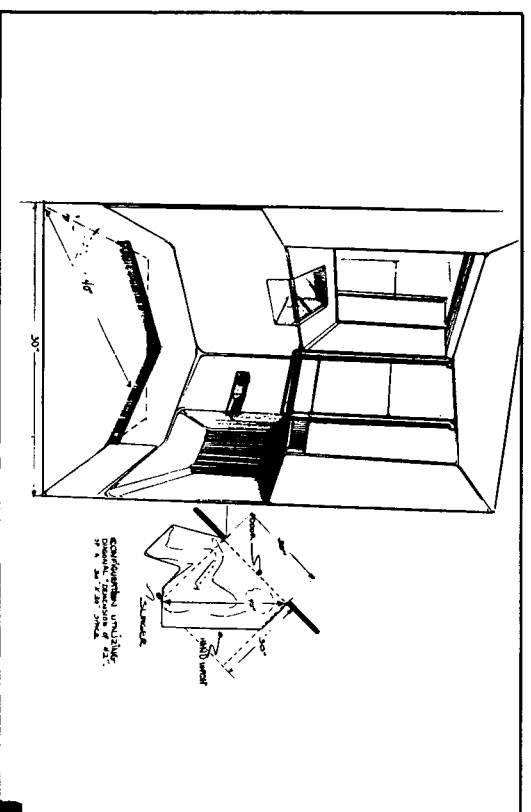




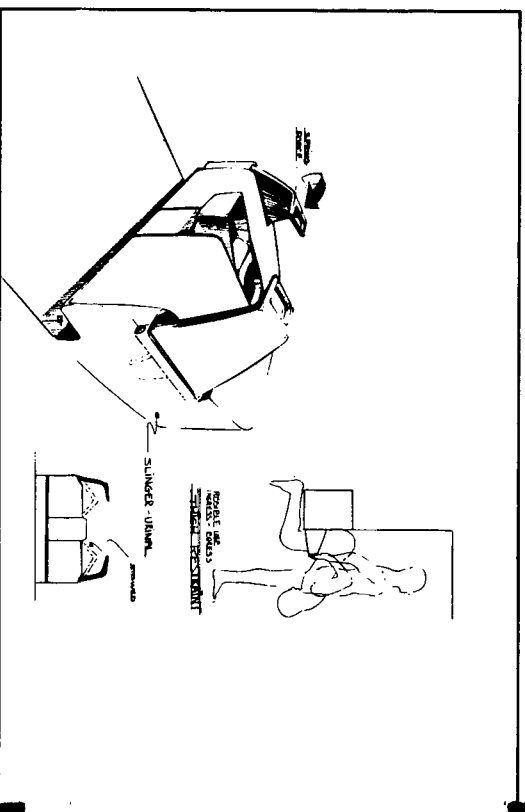
C2 Airline Version of a Hygiene Facility



C3 Economy of Space by Placing Handwash Unit and Fecal Urinal Collector on Adjacent Walls



C4 Hygiene Configuration Utilizing Diagonal Dimension



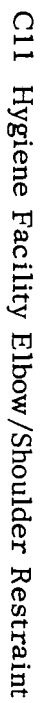
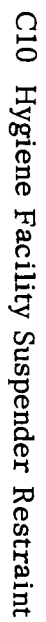
C5 Hygiene Facility Thigh Restraint



SHOULDER / ELBOW PROTECTANT - SHIELDS THE PERSON FROM THE LIFE-SUPPORT CONTAINER WHILE USING THE REEL CHARGER.

FOOT PROTECTANT - PROTECTS THE FEET FROM THE CONTAINER'S REEL AIR HOUSING.

### C9 Hygiene Facility Shoulder Restraint



The arrangement shown on Figure C4 reduces the central maneuvering area of Figure C3 to 30" X 78". By positioning the fecal/urinal collector on a diagonal with the area, a 40" head clearance is attained in a 30" X 30" facility.

A cross section of general comments received on the preliminary critique of the restraint system concepts for the hygiene facility follows:

Figure C5 - Thigh restraint might create pressure disturbing to some crewmen and limit essential body movement. Contact with bare skin undesirable.

Figure C6 - Location of belt restraint too near seat area. Necessity of "D" ring on uniform requires proper apparel.

Figure C7 - Shoulder restraint storage cavity might be a dirt collector. Downward pressure on shoulders may be uncomfortable. Requires static body positioning.

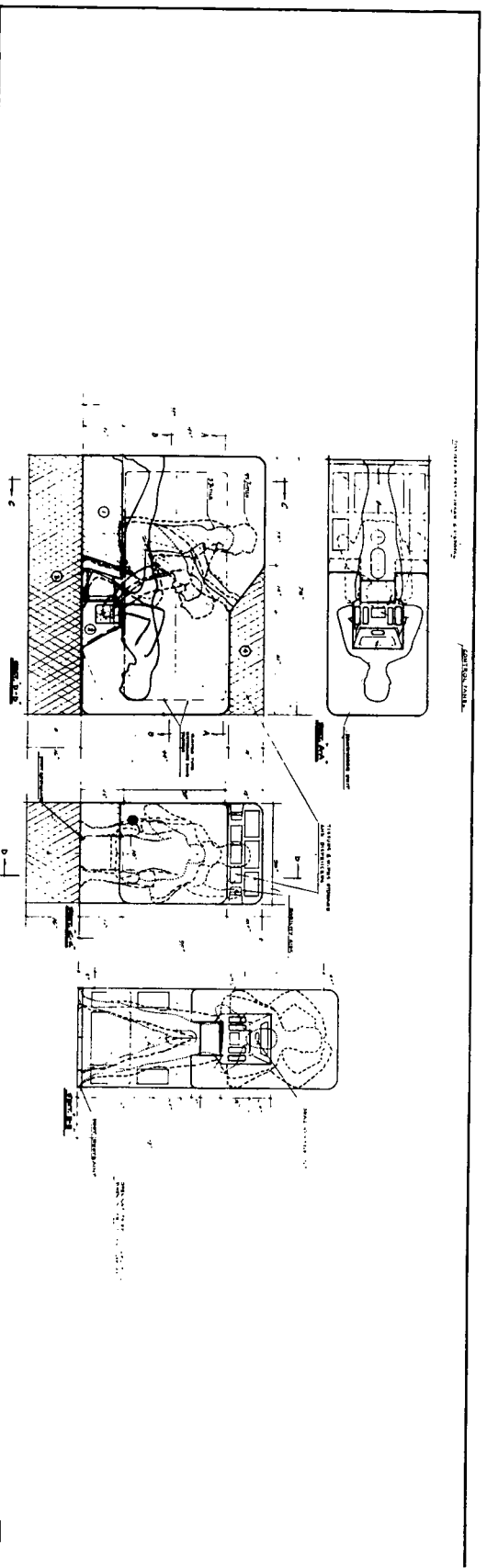
Figure C8 - Thigh restraint might create pressure disturbing to some crewmen and limit essential body movement. Contact with bare skin undesirable.

Figure C9 - Use of elbow or shoulder restraint incorporated with side walls creates possibilities which would give the crewman an option as to the amount of restraint he desires.

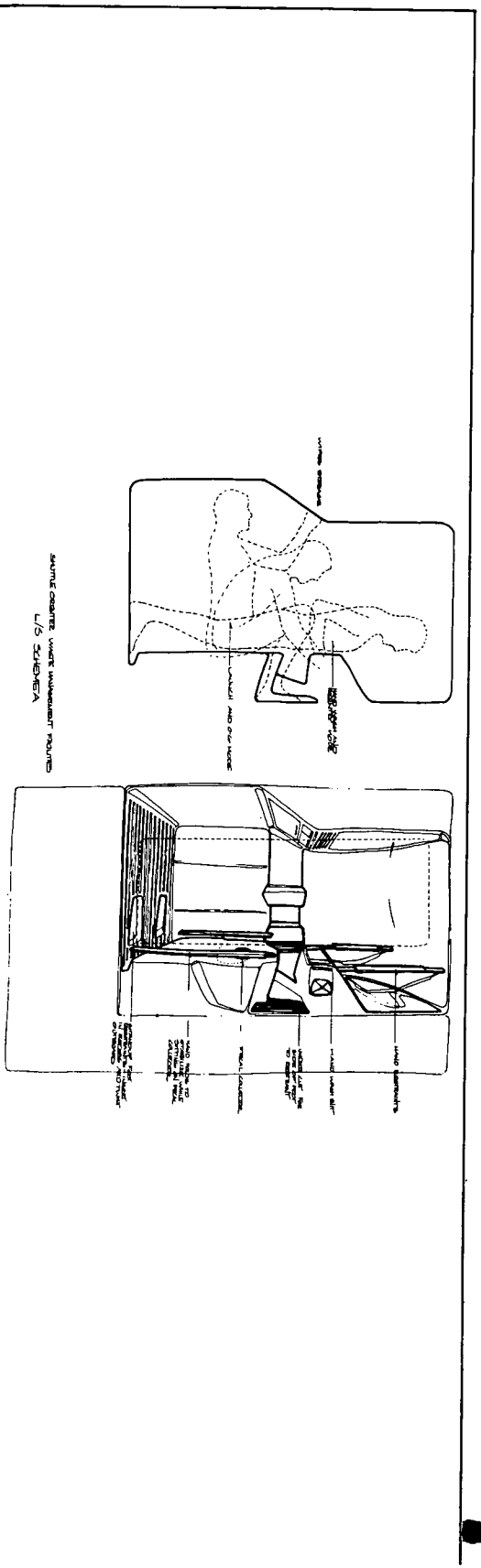
This arrangement allows for location of all facilities requiring plumbing and back-up volume to be in one compact space keeping piping and service runs to a minimum.

LOEWY SNAITH  
APPROACH A  
FIGURES C12-C14





C12 Loewy/Snaith Approach A --- Mechanical



C13 Loewy/Snaith Approach A --- Perspective

All mobility aids and restraints are built in or flush with the adjacent surfaces in the area in which they are located. This approach required the minimum total volume of all concepts studied with no reduction in maneuvering ease.

Figure C14 illustrates Approach A integrated into an MSC, Houston scheme, allowing the vehicle wall curvature to intrude into the compartment without creating a headroom clearance problem previously experienced. Oriented in the shuttle thusly, the handwash unit is now accessible in all orientations.

#### APPROACH B FIGURES C15-C16

This arrangement is somewhat similar to the NASA arrangement; however, by turning the fecal/urinal collector 180°, as shown in Figures C15 and C16, the headroom clearance problem for a person using the urinal/fecal collector is eliminated.

A second urinal opening, leading to the same collector tank, was placed below the fecal opening for standing urination use only.

Mobility aids and restraint provisions are built in or flush with surrounding to the maximum extent possible.

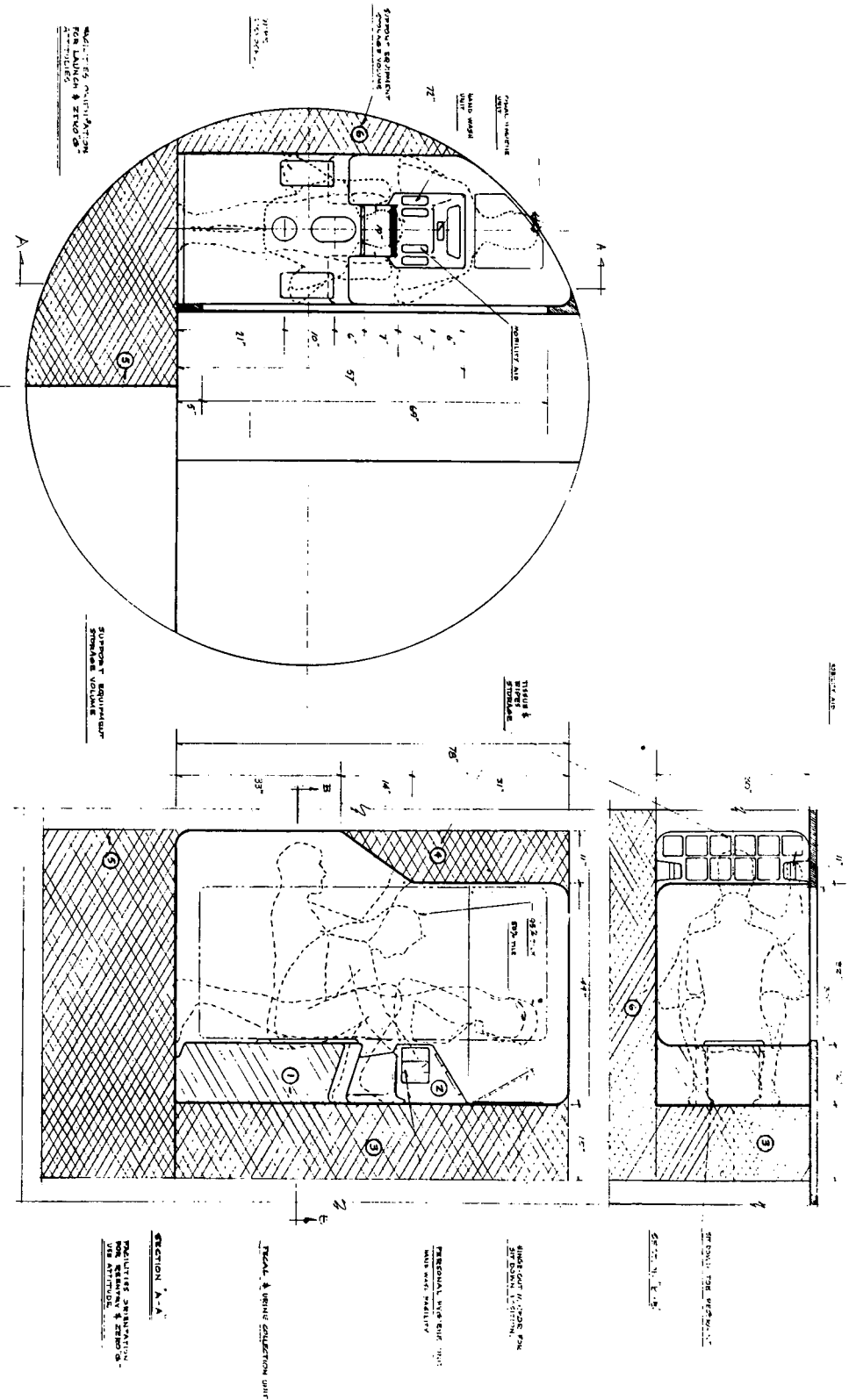
#### APPROACH C FIGURES C17-C18

This scheme positions the personal hygiene unit and fecal/urinal collector perpendicular to axis of shuttle orbiter. The use of waste management units in this orientation varies according to the attitude of orbiter.

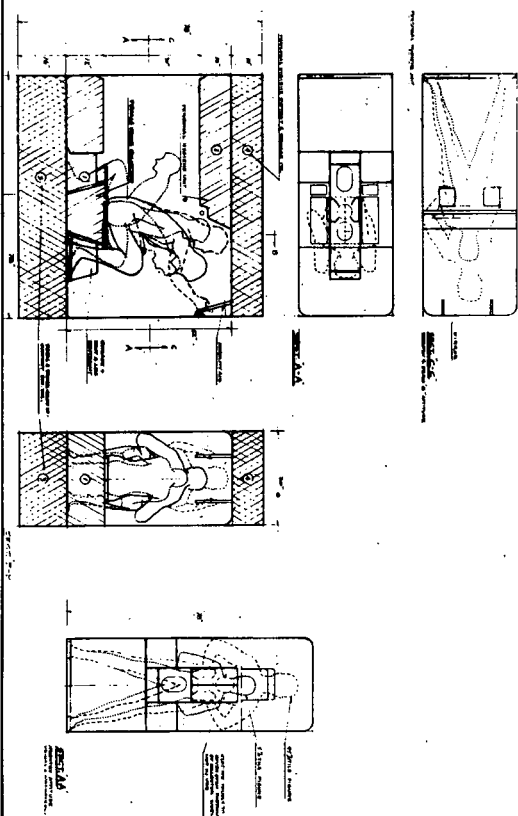
- 1 Launch - Fecal/urinal collector used in seated position. Handwash could be used by side access. Ingress would be accomplished by stepping down through the door into the foot restraint of the fecal/urinal collector.

- 2 Zero-G-All systems in use.

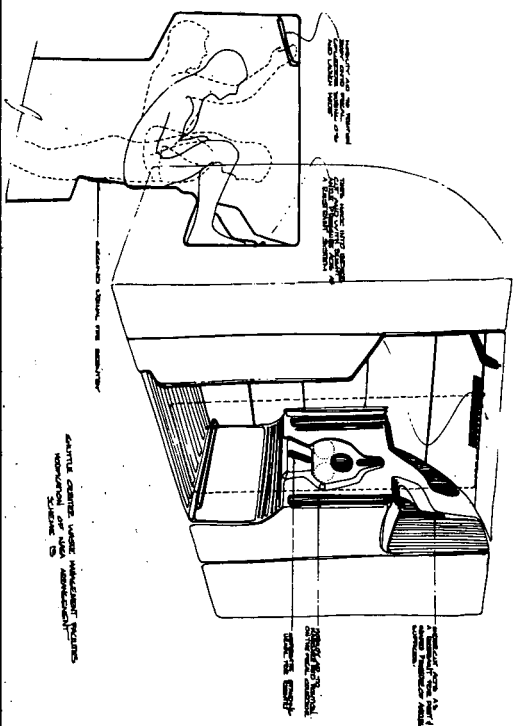
- 3 1-G Flights - Handwash and urine collector are usable. Ingress is accomplished by walking vertically through door.



### C14 Loewy/Snaith Approach A - Integrated into a MSC Scheme



C15 Loewy/Snaith Approach B - Nasa Arrangement with Additional Head Clearance



C16 Loewy/Snaith Approach B in Perspective

FRONT WASH

REAR WASH

STEERING KNUCKLE

WHEEL COUPLING

WHEEL COUPLING

STEERING KNUCKLE

WHEEL COUPLING

— 52.8 Springs  
CLAMP WASH  
WASH.

By placing the fecal/urinal collector and the handwash unit on adjacent walls, excess plumbing and overall equipment volume was minimized.

To take maximum advantage of the space available, we have aligned an individual seated on the fecal collector with a diagonal of the compartment cross section. In addition to making the most of the upper corners, this arrangement locates the round sling in the lower corner taking maximum advantage of that space.

The fecal collector has been positioned low in the compartment relative to the personal hygiene unit to minimize cross contamination. The only change to the personal hygiene unit was the oral hygiene unit being centered over handwash for better accessibility.

## RESTRAINT STUDIES

Throughout this study, Raymond Loewy/William Snaith, Inc. has been concerned with the development of an appropriate restraint system for the hygiene area. The concepts shown on Figure C20, minimize exposed body contact and leaves the eliminating areas of the crewman. We also felt it was essential to give the crewmen an option to the extent of restriction he desired and reduce the feeling of a confined state due to the devices used. By limiting the width of the collection unit (in most schemes to several inches either side of a seated individual) a crewman will be restrained by protruding the elbows into available recesses. Mobility aids have been positioned to aid in function of the facility. Foot and hand aids minimize drift when using the handwash and oral hygiene unit, as well as properly positioning the body in a seated position on the fecal/urine collector.

Figure C21 demonstrates the use of a portable multi-purpose restraint adaptable to the hygiene facility, as well as work stations which require secure temporary position. Carried with the individual crewman around his waist it would be coupled into the unit he was utilizing.

Figure C22 illustrates how a 5% female would use the compartment during Zero-G and 1-G flight modes.

A line drawing of a person in a space suit sitting inside a rectangular module. The person is wearing a helmet and a life support backpack. They are seated on a raised platform. The module has a control panel with a screen and buttons on the right side. A dashed line points from the text below to the person's life support backpack.

RESPIRANT GAS IS SUPPLIED THROUGHOUT THE MISSION, PASSING AROUND OF AIRWAYS OCCUPANT. RELIEVE PUMP IN FINGER END ALLOWS GAS TO BE EXHAUSTED OUT OF SUIT.

PERSONS IN HYDRAULIC CHAIRS  
ARE A REMARKABLE EXCEPTION  
HEATED INTO THEM

PERSONS INTO  
AND CLIP EXPOSURE HEAT

The image contains several technical drawings of archaeological artifacts, likely from a report on the 1957 excavations at the site of Tell el-Faraj. The drawings are arranged in two columns. The left column features a large, long, rectangular object with a central circular feature, a smaller circular feature, and a central slot. Below this are three small human figures in various poses. The right column features a curved object with a central slot, a smaller rectangular object, and three small human figures in various poses. The drawings are labeled with numbers and letters, and some have descriptive text in Arabic.

Figure 1: A long, rectangular object, possibly a tablet or a piece of wood, with a central circular feature. The text "Figure 1" is written below it. The text "هذا هو الشكل النهائي للقطعة" (This is the final shape of the piece) is written to the right of the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object.

Figure 2: A curved object, possibly a piece of wood or a piece of metal, with a central slot. The text "Figure 2" is written below it. The text "هذا هو الشكل النهائي للقطعة" (This is the final shape of the piece) is written to the right of the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object.

Figure 3: A small, rectangular object. The text "Figure 3" is written below it. The text "هذا هو الشكل النهائي للقطعة" (This is the final shape of the piece) is written to the right of the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object.

Figure 4: A small human figure in a standing pose. The text "Figure 4" is written below it. The text "هذا هو الشكل النهائي للقطعة" (This is the final shape of the piece) is written to the right of the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object.

Figure 5: A small human figure in a standing pose. The text "Figure 5" is written below it. The text "هذا هو الشكل النهائي للقطعة" (This is the final shape of the piece) is written to the right of the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object.

Figure 6: A small human figure in a standing pose. The text "Figure 6" is written below it. The text "هذا هو الشكل النهائي للقطعة" (This is the final shape of the piece) is written to the right of the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object.

Figure 7: A small human figure in a standing pose. The text "Figure 7" is written below it. The text "هذا هو الشكل النهائي للقطعة" (This is the final shape of the piece) is written to the right of the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object.

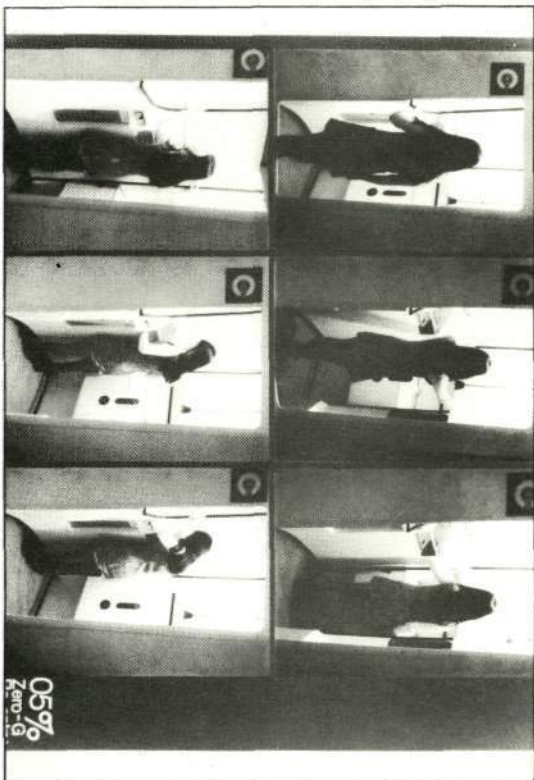
Figure 8: A small human figure in a standing pose. The text "Figure 8" is written below it. The text "هذا هو الشكل النهائي للقطعة" (This is the final shape of the piece) is written to the right of the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object.

Figure 9: A small human figure in a standing pose. The text "Figure 9" is written below it. The text "هذا هو الشكل النهائي للقطعة" (This is the final shape of the piece) is written to the right of the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object.

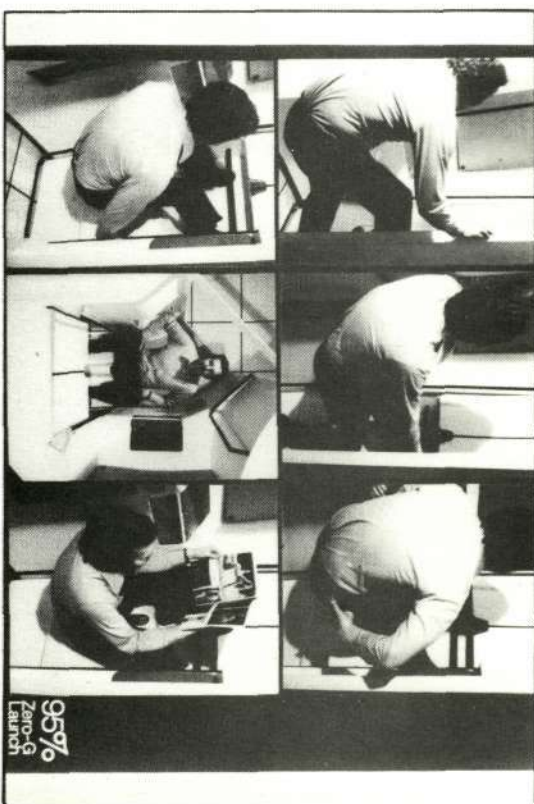
Figure 10: A small human figure in a standing pose. The text "Figure 10" is written below it. The text "هذا هو الشكل النهائي للقطعة" (This is the final shape of the piece) is written to the right of the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object. The text "القطعة مصنوعة من الخشب" (The piece is made of wood) is written below the object.

<sup>21</sup> Portable Belt Restraint

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C22 - 5% Female Compartment Utilization



C23 - 95% Male Compartment Utilization

WASTE MANAGEMENT ARRANGEMENTS VOLUMETRIC COMPARISONS					
NOTE: All figures indicate cubic feet.					
*Area 1 in this scheme.					
**Area 2 in this scheme.					
***Space below tissue and wipes unit.					
Area 4 in this scheme. (Below deck back-up.)					
X indicates step.					
DESCRIPTION OF SPACE	POSITIVE AREA FIXTURES	BACK-UP FIXTURES	TOTAL FIXTURES	BACK-UP FIXTURES	TOTAL FIXTURES
Urinal Collector (Area 1)	10.0				
Urinal and Fecal Collector (Area 4)	6.0*	10.75*	8.3*	7.5*	5.0**
Personal Hygiene Unit (Area 5)	10.0**	8.0**	2.0**	2.25**	16.0*
Tissue and Wipes Unit (Area 4 in this scheme)	16.0	18.75	17.3	17.25	21.0
Area 2 Back-Up (Oral Hygiene)					24.0
Area 3 Back-Up (Behind urinal fecal.)	19.5	21.4	20.7	19.5	26.0
Area 6 Back-Up (Hamilton Standard (Below deck.)	26.0*	11.0*	71.5	79.0	20.0
Below Deck Back-Up (Area 4 in this scheme.)			6.0		
Outer Wall Back-Up (Area 5 in this scheme.)	45.5	14.4	98.2	19.5	111.0
Central Maneuvering Area	42.0	40.6	39.9	40.6	62.0
Space in Front of Collector	1.0X				6.25
Space Above Collector	2.5	4.0		6.6	3.7
Space Below Collector	5.0	5.0	7.0	7.5	5.0
Space Above Personal Hygiene Unit	50.5	51.6	49.7	54.7	51.85
TOTAL NEGATIVE AREA	112.0	104.75	165.2	91.45	166.0

C24 - Waste Management Volumetric Comparisons



Figure C23 illustrates a 95% male using the compartment during Zero-G and launch orientation.

## STUDY EVALUATION

The chart shown in Figure C24 was developed to provide a comparative analysis of the concepts on a volumetric requirement basis. We broke down the facility into maneuvering areas, fixtures and back-up components to figure volumetric relationships.

Based on information gathered from the volumetric comparison, the following observations are noted:

- 1 Approximately 50 cubic feet is required for maneuvering within a hygiene facility.
- 2 The total compartment volumetric requirements is approximately 150 cubic feet utilizing the equipment noted.
- 3 A "lap belt" was considered a necessary "stop gap" device to be used at the discretion of the individual. The pain of cramps will make use of a positive restraining device essential. Problems related to the use of a lap belt system, which must be overcome, include:
  - a Avoidance of contact of exposed skin areas with belt(disposable segment may be direction to explore).
  - b Interference with wipe procedures.
  - c Dirt collection of belt and stowage cavity.
- 4 Required restraints and mobility aids appear to be:

- a Foot restraint/rail (available for use at crewman's discretion).
- b Hand rails (to maneuver between facilities - option of crewman).
- c "Elbow" restraint and/or "Lap" restraint (degree of use - option of crewman).

#### FUTURE EFFORT

Restraint system for a hygiene facility (Phase II) will include effort directed toward the development of an elbow and lap restraint utilizing a revised Approach C.

SECTION D	
TASK	Small Passenger Couch
CENTER	MSC - Gordon Rysavy
DATE ASSIGNED	14 February 1972
PARAMETERS	
1	Serve as a support (seat) for all modes of operation.
2	Reorientation of the couch phases of flight operations will be accomplished by rotating the couch along its longitudinal axis.
3	Provide crewman with comfortable personal area to include provisions for garment, personal gear stowage, trash disposal, tissue dispenser, lighting and communications.
4	Accommodate 5% female - 95% male.
5	Maximum dimensions, 77-1/2"L X 27"W X 14" D.
TASK OBJECTIVES	
Raymond Loewy/William Snaith, Inc. has applied the knowledge and experience gained in the development of a large passenger couch to the small passenger couch. With maximum dimensions of 77.5"L X 27"W X 14"D the couch will perform the same functions as the earlier larger version, as delineated in the parameters above.	

A less pronounced cushion configuration with a low retaining wall, if any, has increased its accessibility and overall usable couch space. Immediate access items, including tissues, trash disposal, personal hygiene kits, etc., have been conveniently located within arm's reach of a restrained crewman. Environmental controls and emergency equipment are included in the couch design.

## SCHEDULE

Following the task assignment, a final presentation date was scheduled for April 4, 1972, with an intermediate preliminary review in March, 1972.

## LOEWY/SNAITH APPROACH

Based on the critique of the first generation space couch, we approached the problem from a structural viewpoint, looking at methods of achieving the most efficient structure and, therefore, the best utilization of available space. By placing the main structural runs under instead of around the perimeter of the couch, we were able to take full advantage of the 27" width. The first generation passenger couch was aimed primarily at developing the trunion support concept to a point which it could be critically evaluated in a three dimensional model. Emphasis was placed on comfort and adaptability to the various flight modes. This effort resulted in a comfortable, but rather large unit (84"L X 36"W X 14"D.) The main storage volume was rather limited and was not accessible when the couch was configured for sleep and the amount of privacy provided was rather limited.

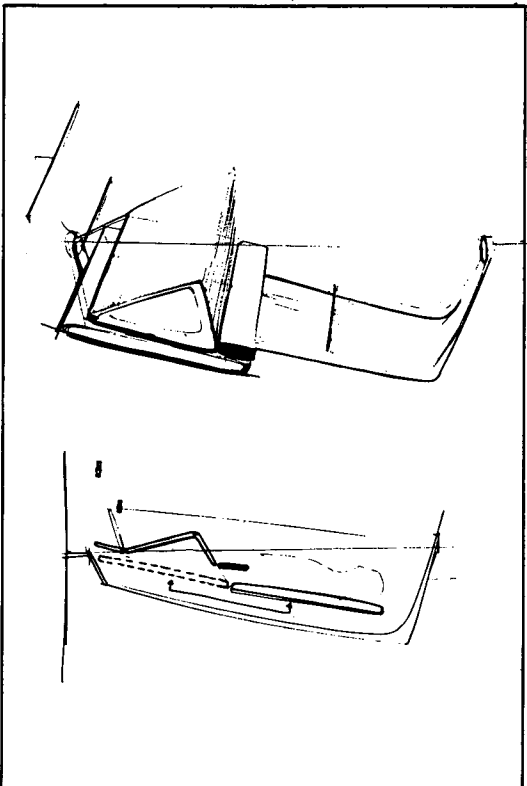
## PRELIMINARY PASSENGER COUCH STUDIES

Figure D1 illustrates the concept of minimizing the structural components and extending the couch padding to provide more usable area for body support. This concept restricts the support to two basic configurations, bent legged for launch and straight legged for sleep. Figures D2 and D3 accomplish this adjustment by revolving the leg section 180° to expose

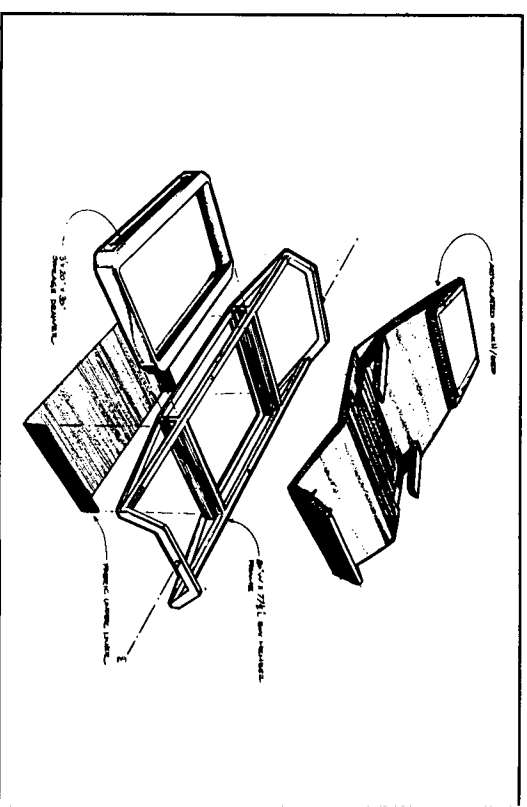
[illegible]

The image contains three hand-drawn sketches of a car's interior and exterior components. The top sketch shows a side profile of a car seat with a headrest, labeled 'HEADREST' with a line pointing to it. The middle sketch shows a car's interior, including the dashboard, steering wheel, and seats, with a line pointing to the dashboard area. The bottom sketch shows a car's exterior, including the front end, headlights, and wheels, with a line pointing to the front end area.

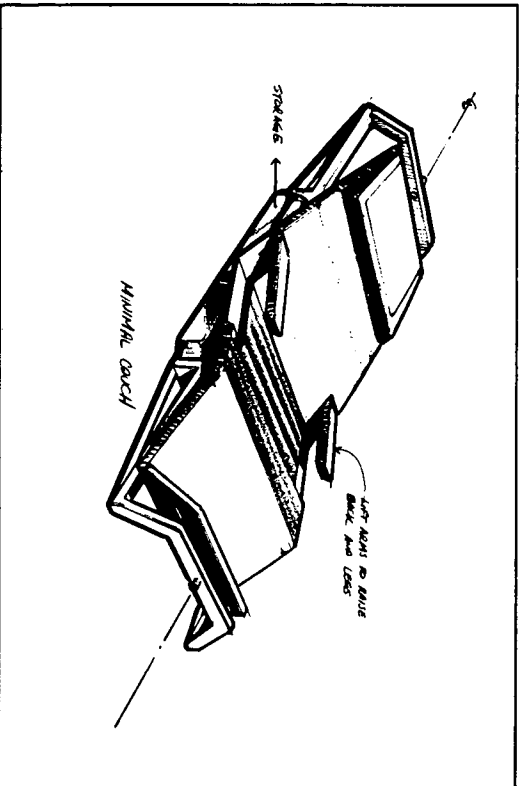
#### D4 Preliminary Adjustable Link Couch



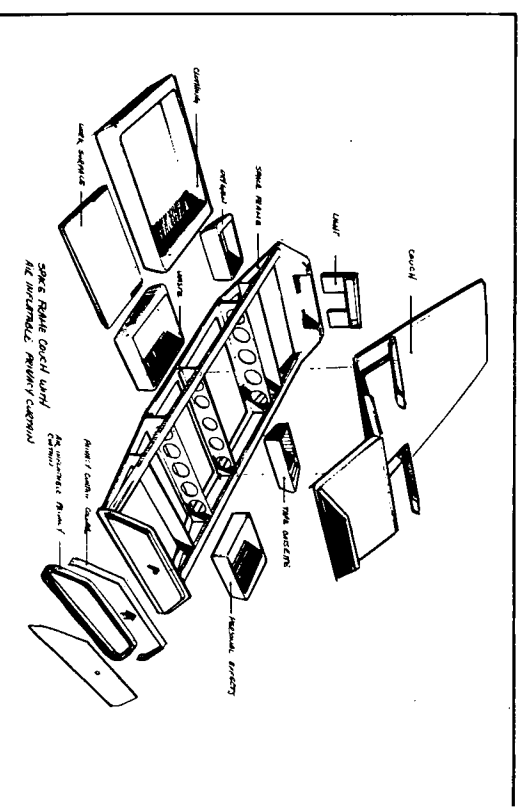
D5 Preliminary Adjustable Link Couch



D7 Minimal Structure Couch - Approach A



D6 Minimal Structure Couch - Approach A



D8 Exploded View of Small Passenger Couch - Approach B

the flat section necessary for the sleep mode. Figures D4 and D5 incorporate an adjustable link which stores flat to reposition the couch from an angled launch and sleep orientation to a flat sleep mode.

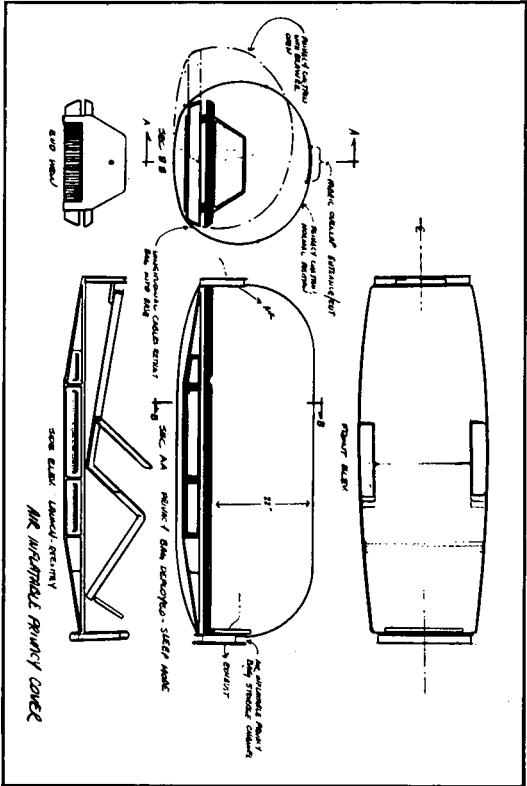
#### APPROACH A FIGURES D2 AND D7

To reduce weight, while creating a number of usable storage cavities, an under the couch space frame approach has been taken. The couch cushion extends the entire usable width of the area with minimum space taken up by the armrests and access to a large storage area is possible from either side of the couch. Fabric is stretched over the back of the space frame to visually lighten and soften the look of the couch. The final configuration development was driven by the need for access to the main clothing storage area from within the privacy area when the couch is configured for sleep.

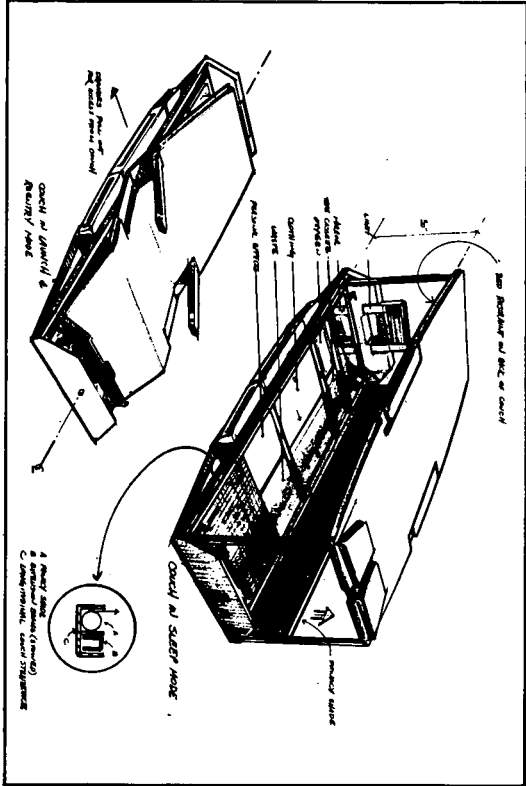
#### APPROACH B FIGURES D13-D16

Configuration "B" increases and segregates the storage area of "A". Space at the far ends has been reduced and would be used for ventilation equipment (if integral) and required electronics (entertainment) not requiring access. The seat back-to-leg length relationship is adjustable through the armrest adjustments.

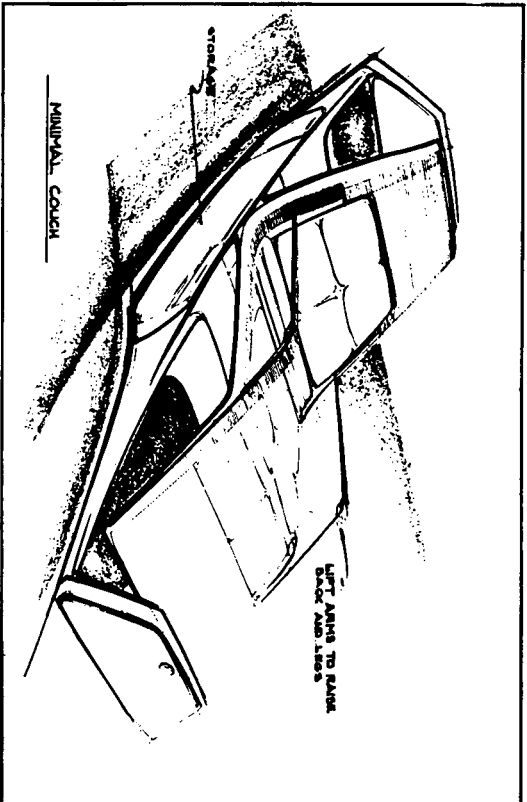
Two sleep compartment configuration concepts are illustrated in Figures D9 and D10. Figure D9 illustrates a concept in which the principle of air-inflatable structures is utilized to provide complete visual privacy and minimum weight. The air structure sleeve would be stowed around the periphery of the couch base (Figure D8). An individual restrained in the couch would break out the privacy sleeve by pulling it up over his head and securing it to the top of the couch. The ventilation unit which supplies air from either the shuttles system or from an independent unit in the top of the couch structure would serve to keep the privacy sleeve inflated. Air leakage would be through the large material over flap area located in front of the restrained individual which also functions as an entrance/exit way from the couch when it is configured for privacy.



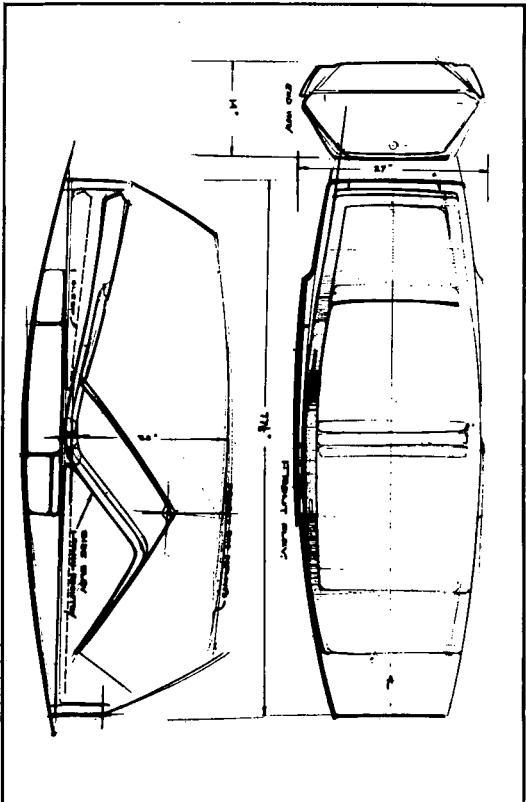
D9 Small Passenger Couch with Inflatable Privacy Screen - Approach B1



D10 Small Passenger Couch with Extension Beam Privacy Screen - Approach B2



D11 Couch Design Configuration - Approach B



D12 Couch Design Configuration - Approach B



B2, the second variation, support rods stored in the structure pivot into a vertical position, raising the couch 24 to 36 inches above the space frame structure. With the couch in this sleep configuration, the crewman would reposition himself on the reverse side of the cushion with accessibility directly to his front to storage modules. 70 inch long curtains recessed in the space frame outboard rails would be pulled up to double as side walls and sleep compartment doors; the resulting compartment resembles in many ways the Skylab crew compartments.

#### APPROACH C FIGURES D13-D16

"C" approach suggests the possibility of combining a conventional couch concept with an airline passenger seat arrangement. Adjustment is limited to two points, the knee location and the back. The couch length is adjusted by shifting the foot pad and seat back in and out.

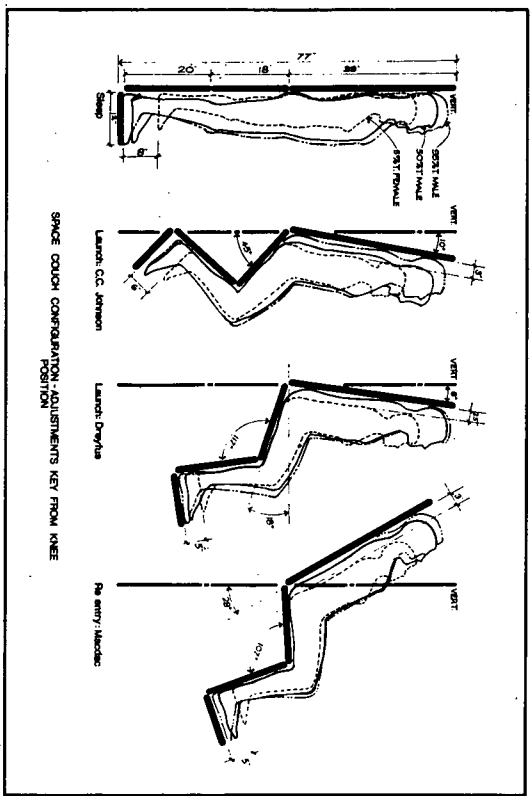
The overnight storage is positioned on a cradle like structure oriented behind or to the side of the couch. For the sleep mode, it is pivoted around the same axis of rotation as the couch to a location in front of the restrained crewman, a privacy screen can be drawn between the two elements enclosing them.

#### APPROACH D FIGURES D17-D20

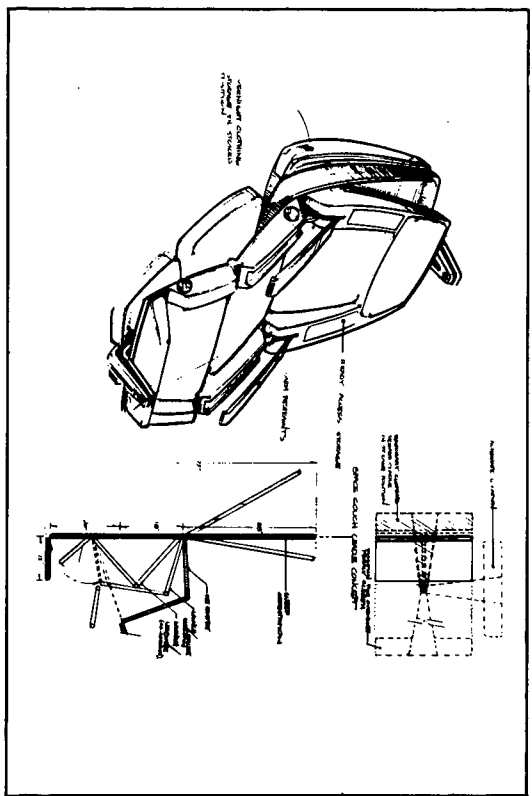
The structure of Concept D surrounds the entire small passenger couch. Within this area the couch is adjusted for two major seat cushion modifications. The first being the bent knee orientation during launch and leisure configurations.

The overnight clothing storage is located behind the seat back. Immediate access items including oxygen, tape deck, etc., may be placed in storage located between the legs of the base of the couch.

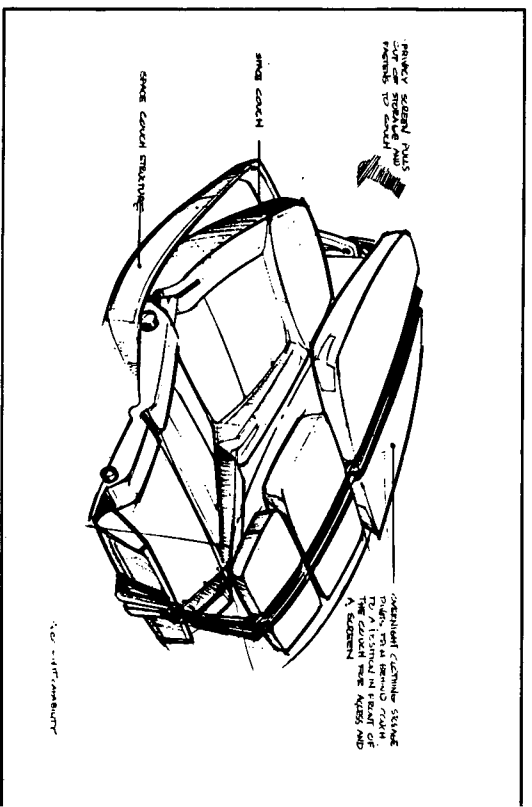
In the sleep mode, a canopy unit pivots along the axis of couch rotation from behind, to a position over the crewman's head.



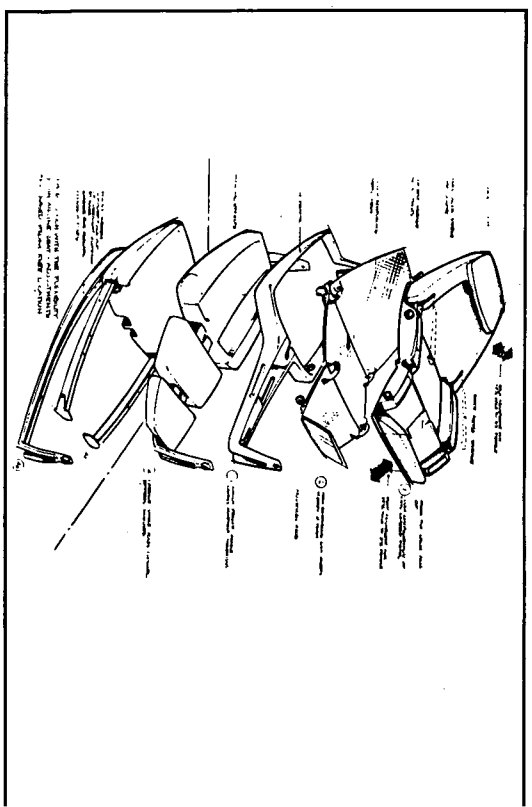
D13 Space Couch Configuration - Adjustments key from Knee Position - Approach C



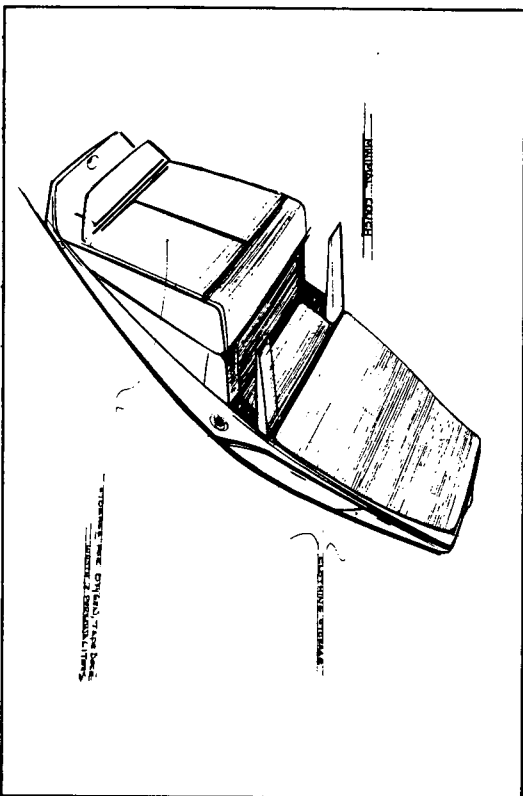
D14 Small Passenger Couch Cradle Concept - Approach C



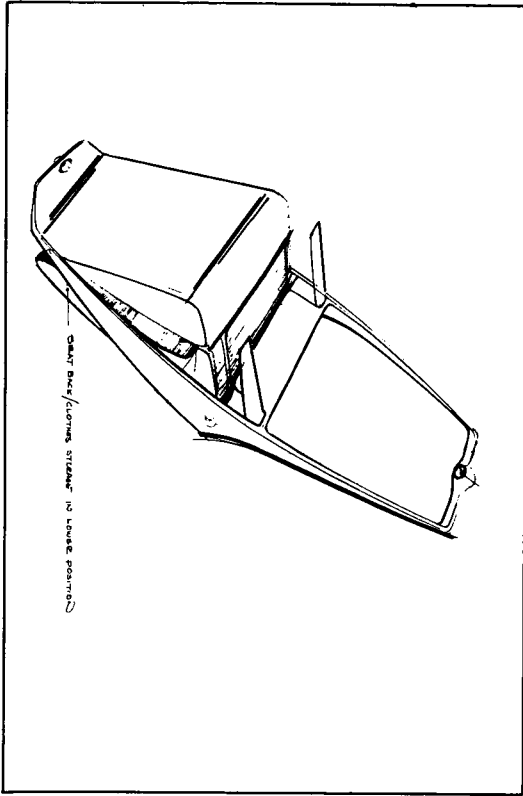
D15 Small Passenger Couch Cradle Concept - Approach C



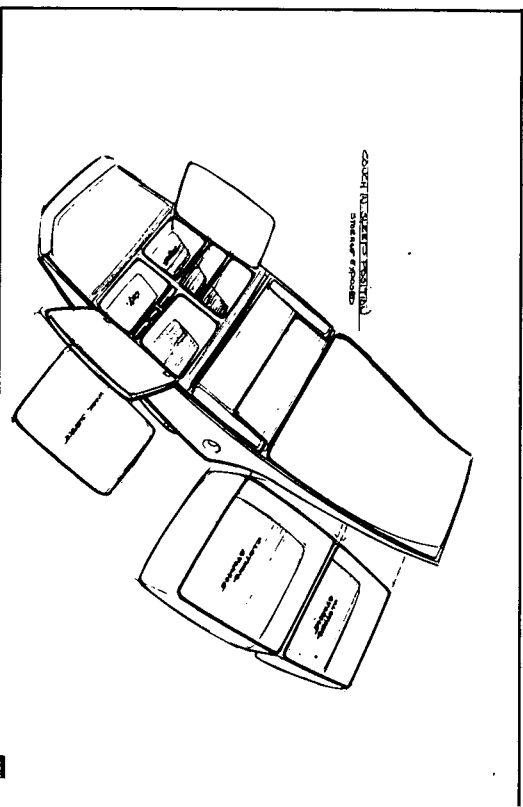
D16 Cradle Concept - Approach C



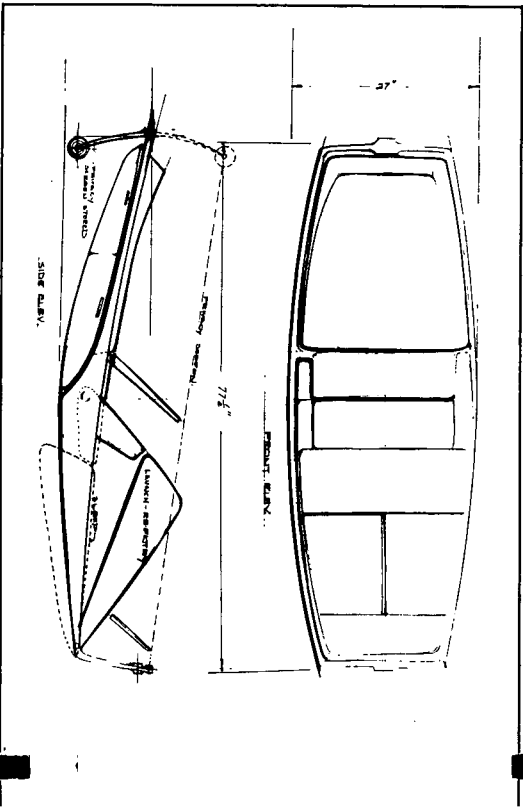
D17 Small Passenger Couch Pivotal Link Configuration - Approach D



D18 Pivotal Link Configuration - Approach D



D19 Link Couch Storage Compartment - Approach D



D20 Link Couch Schematic - Approach D

# **SMALL PASSENGER COUCH STUDY COMMENTS**

The integral sleep compartment concepts of Scheme "B" and volume reduction of Scheme "D", were considered desirable features. A breakdown requirement for the couch to fold to 28"W X 28"D X 39"L was introduced late in the concept development to allow for removal of the couch from the station was not considered in this study phase. In general, the study established the credibility of the small passenger couch concept.

SECTION E	
TASK	Food System and Galley
CENTER	MSC - Gordon Rysavy
DATE ASSIGNED	14 February 1972
PARAMETERS	
1	42 man days (6 men/7 days - 14 men/3 days).
2	3 meals per day with limited choice per meal.
3	One-man food preparation and clean-up.
4	All food and equipment related to the galley function to be stored in the unit.
5	Galley volume 100 cu. ft. (80 cu. ft. galley facility - 20 cu. ft. house-keeping).
6	All foods will be precooked, packaged and served in individual containers. (Food type: dry 50%, shelf stable 30%, and perishable 20%).
7	Frozen foods will not be considered for the 42 man/day mission.

## TASK OBJECTIVES

To develop food system and galley concepts which emphasize:

- 1 Minimize time, decisions, and skills required.
- 2 Use of conventional food preparation systems.
- 3 Human factors layout to reflect frequency of use of various units.
- 4 Provide for selection of courses per meal.
- 5 Provide for snack and leisure foods.

## SCHEDULE

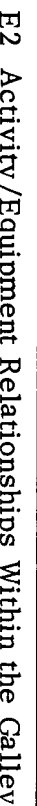
The initial review meeting was scheduled for April 26, 1972.

ANALYSIS OF  
EXISTING CONCEPT  
FIGURE E1

MSC Houston's existing concept has a total volume of 113 cu. ft. which includes 33 cu. ft. of working volume and 80 cu. ft. of hardware volume.

Positive

- 1 Work counter is directly to the front for viewing ease.
- 2 Attendant not required to stand in congested area.
- 3 Storage units and preparation equipment are limited to an armspan width.
- 4 Semi-enclosed area confines spillage, but does not isolate attendant.



ACTIVITY	EQUIPMENT	
Menu Selection	Oven	MEAL PREPARATION EQUIP.
Meal Preparation	Refrigerator	
Tray Loading/Pick-Up	Portable Water System***	
Tray Drop-Off	Water Injector	
Clean-Up	Tray Dispenser	
Waste Collection	Menu	
Snacks	Area Clean-up Equipment****	STORAGE
	Snack Food and Beverage Storage	
	Eating Aids*	
	Meal and Beverage Storage	
	Cleaning Agents	
	Wipes	
	Galley Attendant	RESTRAINTS
	Unpackaging	
	Food Preparation	
	Environmental Controls**	MISCELLANEOUS
	Equipment Controls	
	Work Surface	
	Emergency Oxygen	

ACTIVITY/EQUIPMENT RELATIONSHIPS

(X) indicates a relationship and need for access.

\* Trays, utensils and beverage containers.

\*\* Lighting, temperature, intercom.

\*\*\* Water supply tanks, chiller, heater.

\*\*\*\* Includes: collection containers, storage bags, wet and dry wipes, vacuum cleaner.

### Negative

- 1 Refrigerator access requires attendant to step back and bend.
- 2 Duplication of volume creates unnecessarily large galley.
- 3 Dispersed placement of preparation facilities requires frequent body maneuvers by the galley attendant and added time in meal selections.

## STUDY ANALYSIS

### 1 Activity Equipment Relationships

The relationship between the activities performed in the galley and specific pieces of equipment have been illustrated in Figure E2. The chart emphasizes the necessity of locating some units for specific tasks within close proximity and the need for their access during a particular function.

### 2 Menu

To insure the crew obtains the proper amount of nutritional content within their food, he will be asked to eat certain types of foods. Before launch, the crewman will select the food he desires during the mission, subject to dietitian approval. In flight, he will have the choice of selecting which meals he will eat on a specific day.

### 3 Selection

For the purpose of this study, the types of food available was limited to seven categories: meats, vegetables, starch, soup or salad, bread and desert. A selection of two vegetable types was possible. A single soup and salad choice was offered.



## 5 Food Volumetric Quantities

Food volume quantities are based on the fact that 7 food cans are the maximum available per meal per man. This results in a total of 882 food cans necessary to supply 6 men for a 7 day mission.

## 6 Restraint Systems

Food preparation requires that the attendants have both hands free. 'Hands free' restraint concepts have, therefore, been developed.

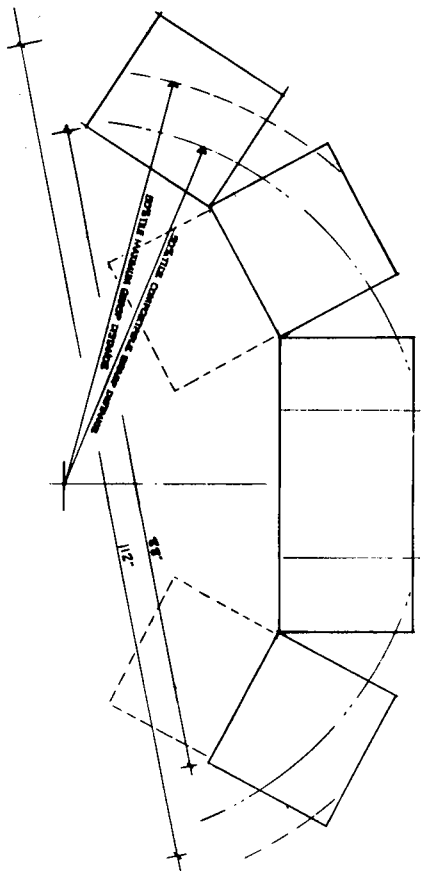
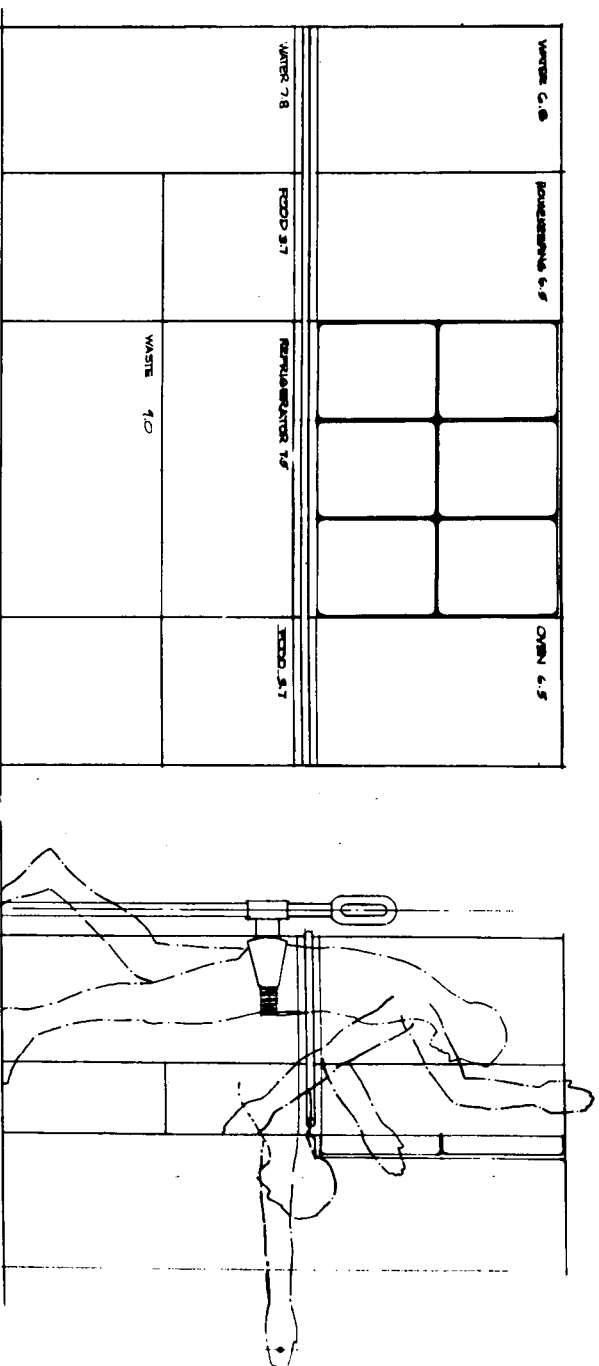
## APPROACH A FIGURES E3-E7

To minimize volumetric requirements of the system and to increase the amount of work and storage area accessible to the attendant, this scheme orients the galley around the outside curvature of the vehicle and utilizes a radial arm restraint system which allows the attendant to move as required. Built of modular units, additional storage components may be included as the size of the crew increases.

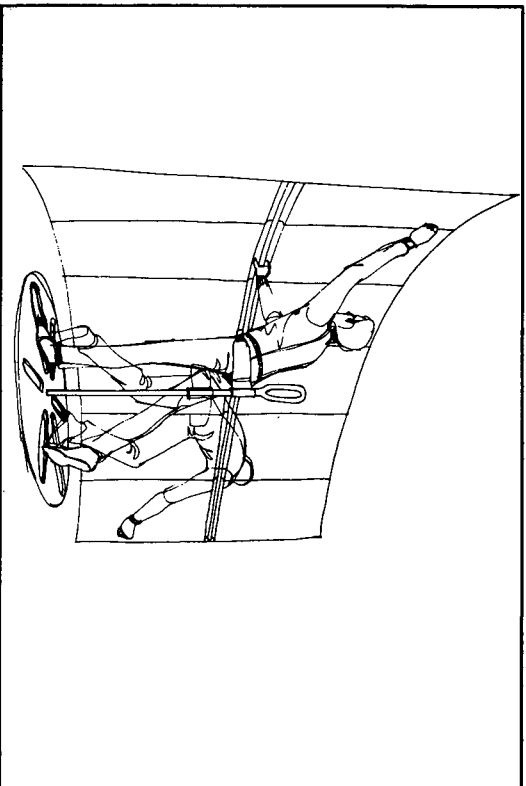
Prior to meal service, the crewman selects what food items he desires and locates them on individual sliding preparation racks by food type. After necessary rehydration or heating, the cans are placed in individual serving trays.

The counter surface utilizes the vertical surface in front of the attendant upon which six food trays are placed.

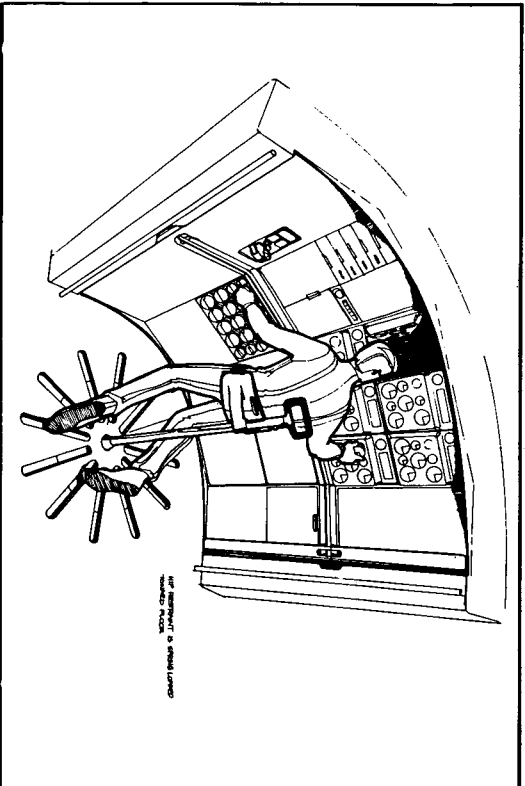
At the meal's completion, the food trays are returned to the galley and placed into their cavities. Empty cans are placed into the waste container.



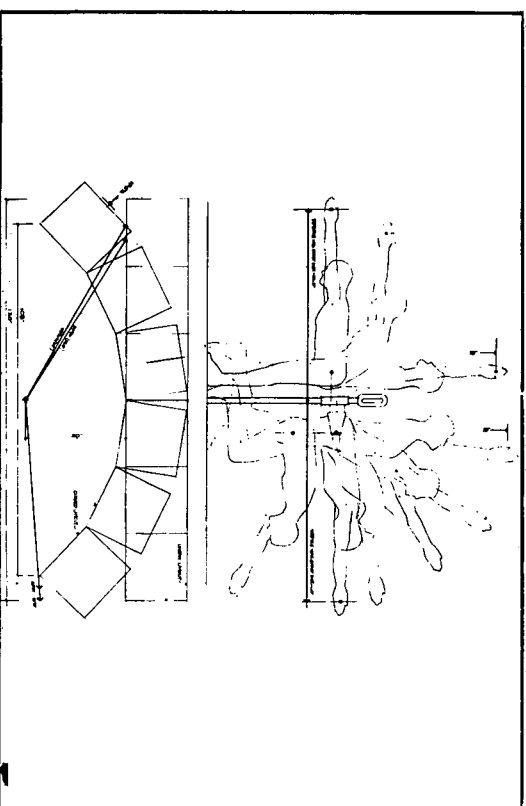
E3 Galley Concept - Approach A



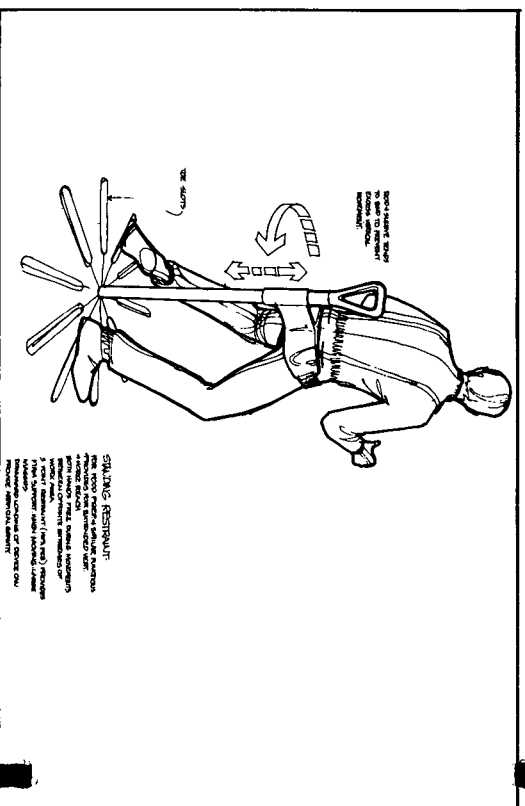
E4 Restraint Device - Approach A



E5 Galley Perspective - Approach A



E6 Galley Restraint Schematic - Approach A



E7 Restraint Perspective

## APPROACH B FIGURES E8-E11

To limit the amount of involvement which is required by the attendant, Approach B eliminates the food heating procedure. Heating coils in the food trays enable individual crewmen to warm their own food at their convenience without requiring a minimum of the breaking out and organizing of individual courses.

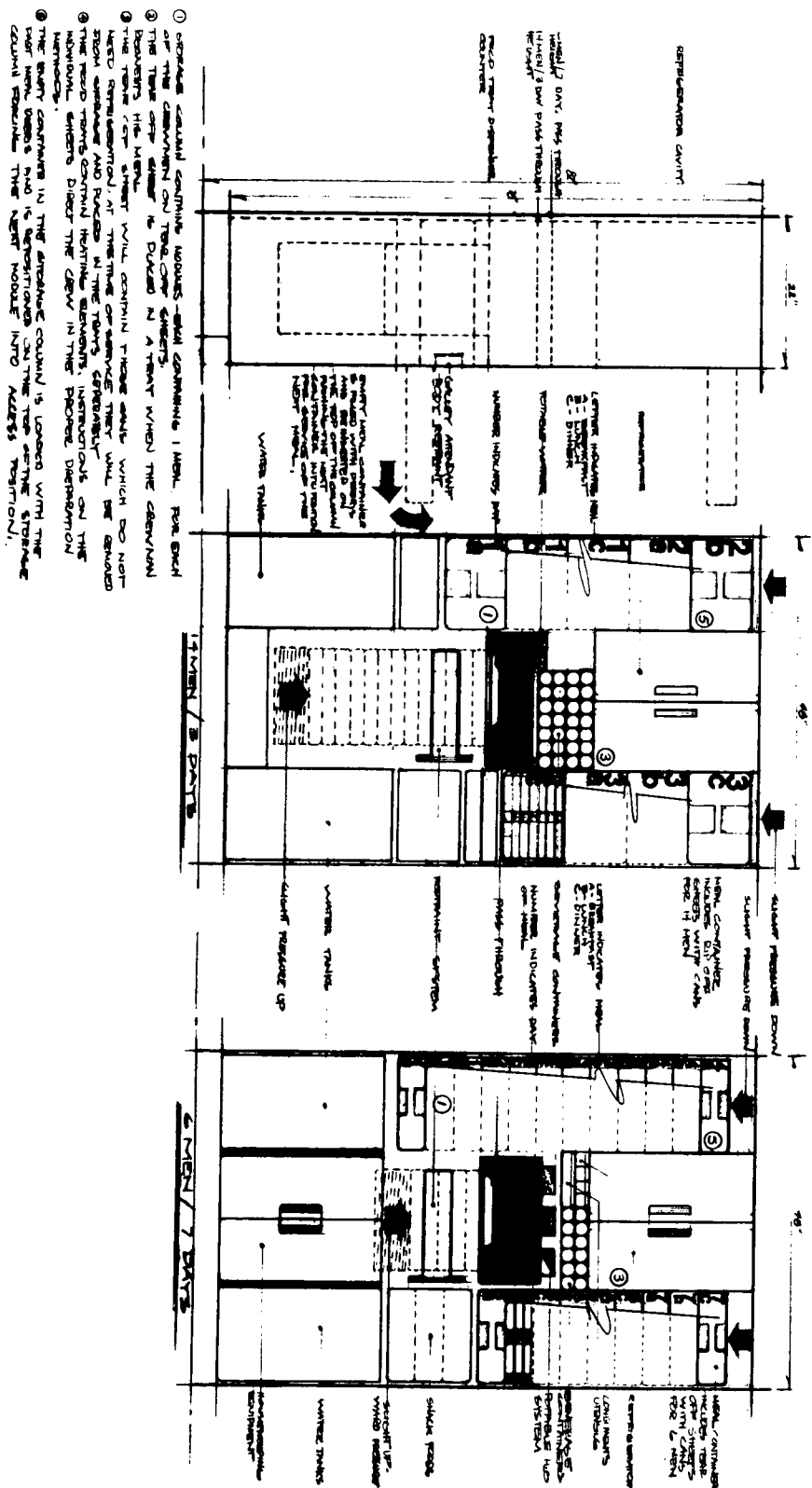
Before the mission, each crewman has the opportunity to select the meal he desires on a particular day. They are then packaged in modules identified for a particular day and meal. A crewman may interchange any meal by notifying the attendant.

The entire meals come on "tear-off" sheets. The sheets are aluminum backed which double as a protective soil mat, while on the trays.

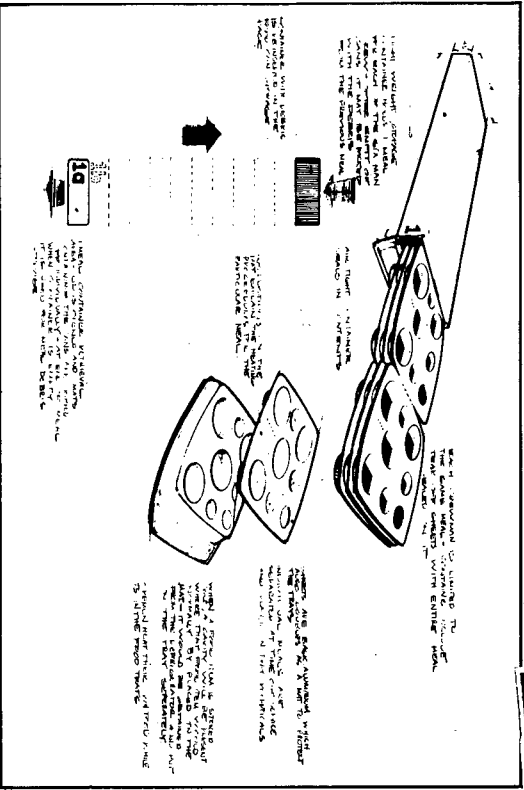
Those cans requiring rehydration are placed in the tray receptacles. When a food item is stored cold, a cavity is present on the sheet. The directions on the tray direct the attendant as to which food item is required.

If a crewman were to eat off schedule, he would obtain his tray which had been pre-loaded by the attendant, and select his beverages, utensils and condiments which are stowed above the tray lowerator. The tray is then plugged into the galley or the crewman's couch to bring the food to the proper temperature.

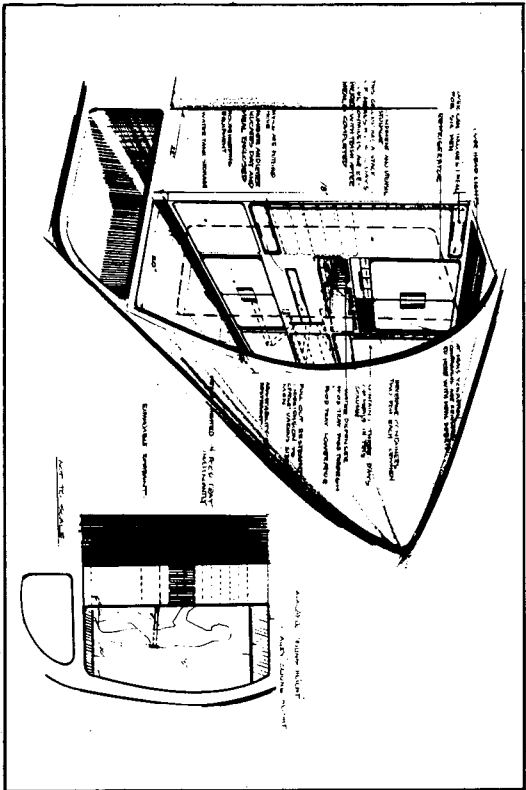
When an individual returns his tray, he places the tear-off sheet with the attached, now empty, food cans, into the waste storage module. Once filled with all 6 (14) tray inserts, it is sealed and repositioned on top of the column from which it was retrieved. A slight pressure forces the next meal module into the access area.



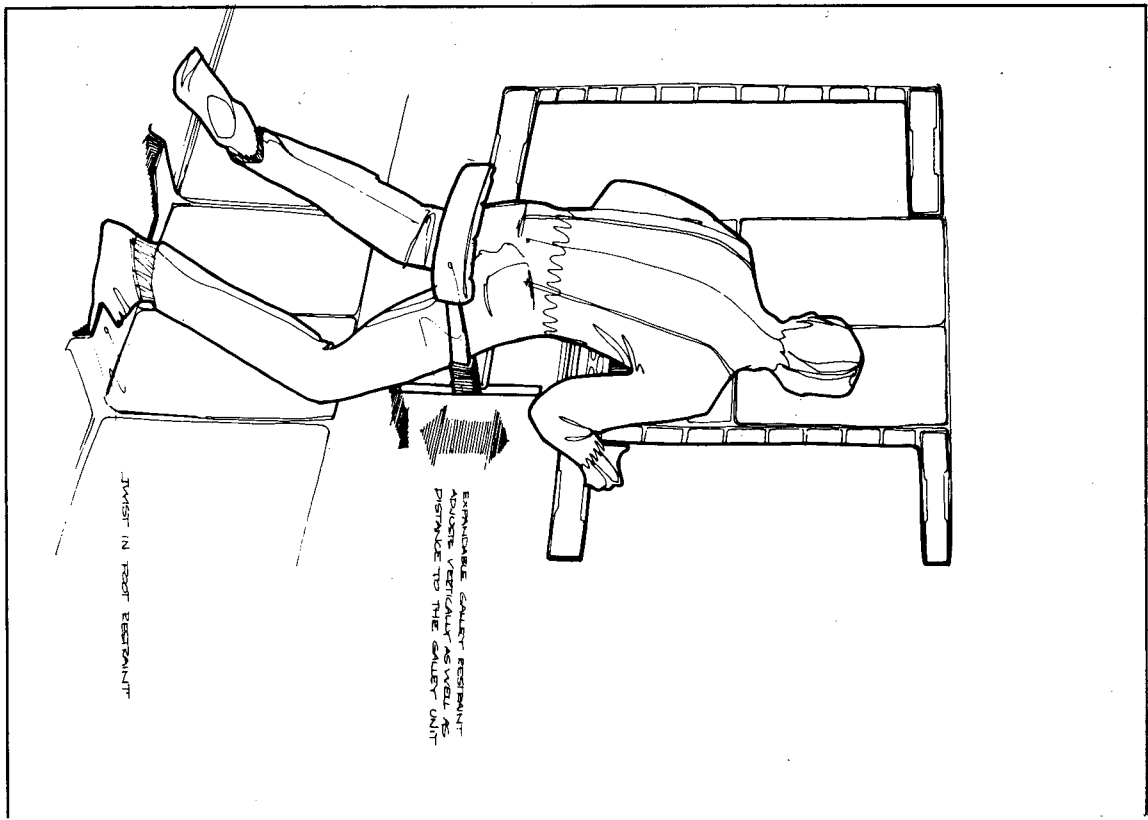
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E9 Module of Six Meals on Tear Off Sheets



E10 Perspective of Possible Orientation Within Craft



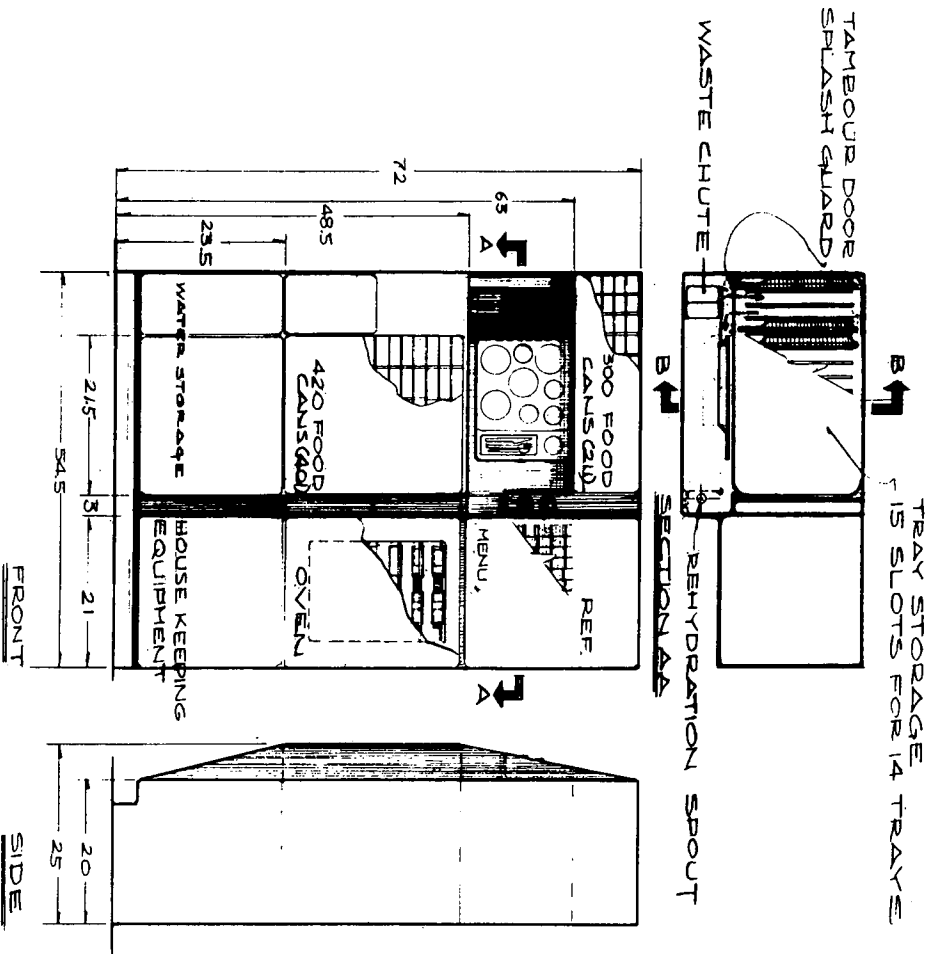
E11 Adjustable Restraint

APPROACH C  
FIGURES E12-E15

Each crewman is allowed to substitute any food item on a given day, without adversely affecting the meal preparation by the attendant. Rationale for the following approach includes:

- 1 Compact layout enables operation from a single fixed restraint point.
- 2 Prime work functions easily viewed including display, water dispenser, counter storage and waste unit.
- 3 The area, situated immediately below the display, is accessible for easy reference to hot items list.
- 4 Food storage areas surround the primary work area and are adjacent to the oven.
- 5 The rehydration unit is centrally located between food storage areas with beverage dispensers and utensil storage immediately below.
- 6 Waste disposal chute is located at extreme left of work counter. This provides easy access when emptying trays, yet removes it from prime preparation areas.
- 7 Housekeeping equipment and water storage are located at the base of the unit, since access would not normally be required during food preparation.

Access to the food cans is simplified by linking them together in pigeon-holes with an identifying perforated tape. By pulling on the tape "pull tab", the required number of cans of a given type may be removed. When the tape is parted, the remaining cans stay at the front of the pigeonhole for access when next needed.



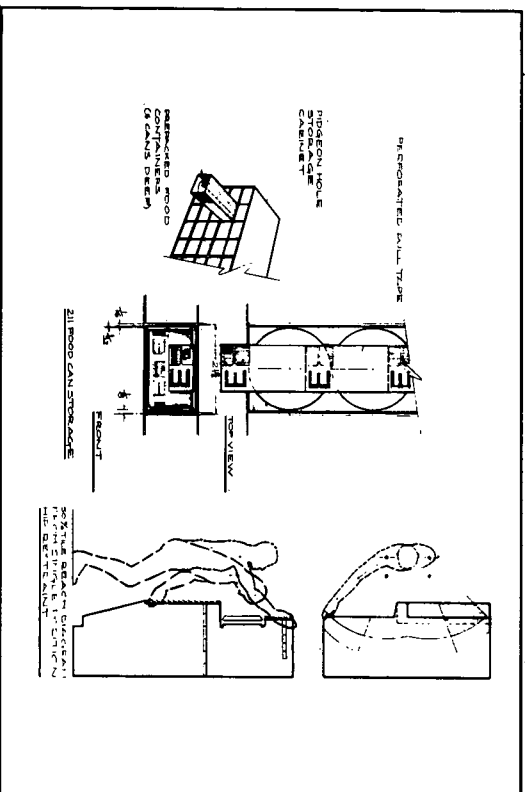
#### LOADING SEQUENCE

- ① INDIVIDUAL MENUS PLACED ON MENU CONTROL BOARD.
- ② HOT ITEMS READ FROM MENU, LOCATED, & PLACED IN OVEN TRAYS. \*
- ③ AMBIENT & CHILLED ITEMS READ FROM MENU & PLACED IN SERVING TRAYS.
- ④ HOT ITEMS REMOVED FROM OVEN & ADDED TO SERVING TRAYS
- ⑤ BEVERAGE IS SELECTED & PREPARED AT TIME OF TRAY PICK UP.

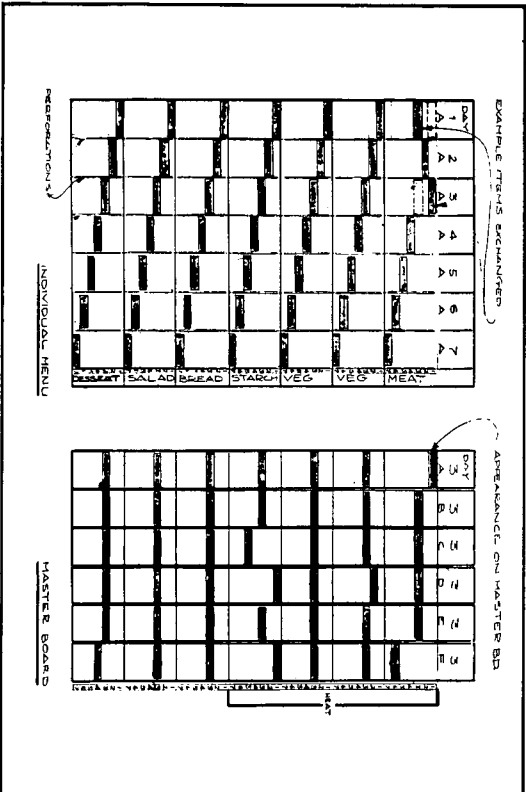
#### CLEAN UP SEQUENCE

- ① SOILED TRAYS RETURNED TO TRAY RACKS BY USER.
- ② TRAYS ARE INDIVIDUALLY REMOVED FOR CAN DISPOSAL & CLEANING.
- ③ CLEAN TRAYS ARE RETURNED AGAIN TO RACK FOR NEXT MEAL

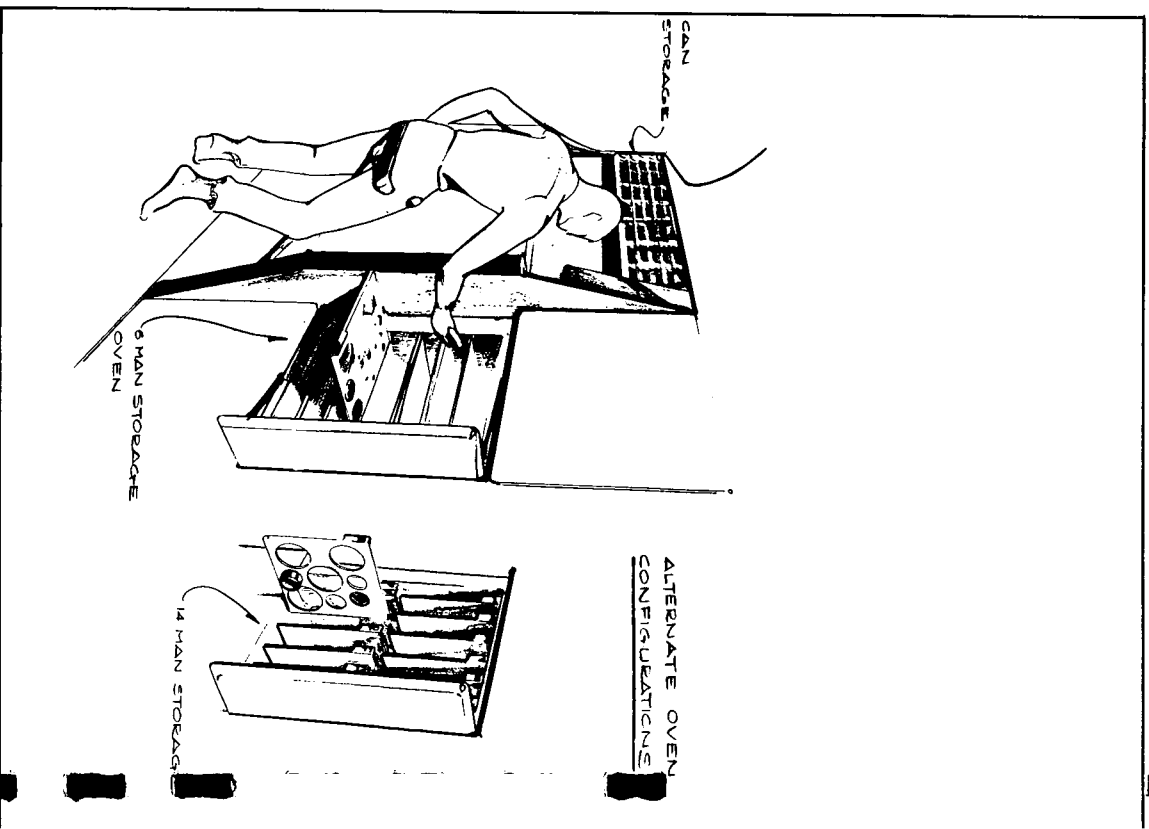




E13 Identification and Storage Technique of Food Cans



E14 Individual and Master Menu Cards



E15 Perspective of Attendant Preparing Meal - Approach C

Three menus are issued to each crewman representing the three meals of each day for this mission duration. Meal items are printed on adhesive labels which are pre-arranged on the menu. Labels would indicate in which of the three storage areas an item may be found. Should the crewmen desire it, he could interchange any meal item within the scope of the items offered that day. After receiving the selected menus, the attendant would arrange them on a master board which provides graphic aid in determining which foods must be heated and where they are found.

Water is added to those items requiring rehydration and those items which require heating are placed in the hot air convection oven. Fourteen racks identified by person hold cans in the same position as they occur on serving trays. Ambient items on the menu are then placed in serving trays. When prepared, the items in the oven are removed and placed in appropriate trays followed by chilled foods.

The prime work area serves the dual purpose of tray display and tray storage area. The storage area includes slots for the 14 trays. The trays and slots are identified with the crewman's name and number.

Beverages are prepared by the individual crewman at the time of tray and utensil pick-up.

Soiled trays are returned to tray racks by the user. Cans are disposed of and the tray is cleaned and returned to the rack for the following meal.

#### Study Results (Figure E16)

The chart summarizes the relative volumetric requirements of different units. From the results, it appears that the total volume for a food system and galley need not exceed a 56 cu. ft. excluding standing volume. This figure is sufficient to include all necessary hardware.

FOOD SYSTEM AND GALLEY ARRANGEMENT					EQUIPMENT
Approach C	Approach B	Approach A	MSC Requirement Study		
11.1	13.4	7.4	7.0		FOOD STORAGE
5.5	*	6.5	5.5		OVEN
5.5	6.1	7.5	5.5		REFRIGERATOR
7.6			5.1		POTABLE WATER
.2			.3		Heater/Chiller
			2.0		System
7.8	8.0	9.2	7.8		TOTAL POTABLE WATER
2.0	1.8	N. A.	47.3		WORK COUNTER VOLUME
6.5	2.2	6.6	6.5		HOUSEKEEPING
3.4	13.4	9.0	4.0***		WASTE
4.9	9.5	2.5	N. A.		TRAYS
1.0	1.9	1.2	1.2		CUPS AND UTENSILS
N. A.	N. A.	80.0	N. A.		STANDING VOLUME
55.4	56.3	49.9	92.2		TOTAL HARDWARE VOLUME
55.4	56.3	129.9	92.2		TOTAL VOLUME

## FOOD SYSTEM AND GALLEY RELATIONSHIPS

\*Food heated in tray.

\*\*Food storage modules are used.

N.A. Not Applicable

\*\*\*Included in housekeeping.

SECTION  
F

TASK Temporary Restraints

CENTER MSC - Gordon Rysavy

DATE ASSIGNED 14 February 1972

## PARAMETERS

- 1 Accommodate all necessary clothing apparel.
- 2 Ease of access from a single restraining point.
- 3 Overnight garment storage to include: 1 pair slacks, 1 shirt, 1 jacket, 1 pair briefs, 1 pair socks, 1 pair shoes.
- 4 Target size: 30" X 24" X 4" minimum 1.67 cu. ft. (MSC Study 30" X 40" X 5" minimum Martin Marietta Neutral Buoyancy Study).
- 5 Mission Duration: 7 days.

## TASK OBJECTIVES

In the development of the overnight clothing storage, particular emphasis was placed on the prevention of odor cross-contamination. It was felt that the different levels of odor producing garments should be segregated into isolated areas to prevent soiling of relatively cleaner items. A downward ventilation flow minimizes odor transfer, perhaps an extension of the existing circulation system. Established odor sequence (low to high) follows: pant's jackets, socks, shoes, undershirt and briefs.

Clothing should be stored in such a manner as to permit adequate ventilation around it and prevent garments from becoming wrinkled.

The overall dimensions of the garment restraint systems developed were kept to a minimum.

The position of garment fasteners and the location and size of the odor barrier dictated the final configuration and volumetric requirements. Figure F1 represents the garment restraint study guidelines which lists the required items to be stored by dimensional requirements. These volumetric requirements represent the volume required to contain a particular garment in a wrinkle free state. By calculating the total area encompassed by the items, a total storage volume can be established.

Figure F2 and F3 show two accepted layouts. Scheme A, measuring 29"W X 43"L (1,232 sq. in.) and vertically divides the odor areas. The high odor producing items are placed near the base of the storage unit with air flow directed downward. The garments have been organized with the jacket and shirt to the left and trousers and briefs to the right.

Scheme B, measuring 31"W X 43"L (1,230 sq. in.), positions the higher odor producing garments, i. e., trousers, briefs and shoes near the bottom of the storage unit.

ANALYSIS OF  
EXISTING MSC CONCEPT  
FIGURE F4

1

Soiled clothing storage is included with clean garments and personal gear - odor transfer from soiled to clean items apparent.

GARMENT RESTRAINT STUDY GUIDELINES									
Item*	Req'd. Temp. Show Each	Cu. Inch Vol. Req'd. Temp.*	Req'd. Show Vol. Req'd. Temp.*	Cu. Inch Vol. Req'd. Temp.*	Req'd. Show Vol. Req'd. Temp.*	Cu. Inch Vol. Req'd. Temp.*	Probable Packed Dimensions		
		14 Men	14 Men	6 Men	6 Men	7 Days*			
Socks (Pair)	1	60 = 8 X 5 X 15	1	7.5	3	30	8 X 2.5 X .4		
Shoes	1	360 = 12 X 10 X 3	0	0	0	0			
Briefs	1	200 = 10 X 10 X 2	1	50	3	150	2.5 X 2.5 X 6		
Shirt	1	509 = 14 X 18 X 2	0	0	2	100	2.5 X 2.5 X 6		
Trousers	1	320 = 12 X 16 X 2	0	0	1	125	10 X 12.5 X 1		
Jacket	1	509 = 14 X 18 X 2	0	0	0	0			
		580 = 2"D X 1"W Linear Sep.							
	2,428			57.5		405			

\* No change is foreseen in the garments for women. It is assumed that special supports would be seen into existing undergarments.

\*\* Figure does not include interfaces.

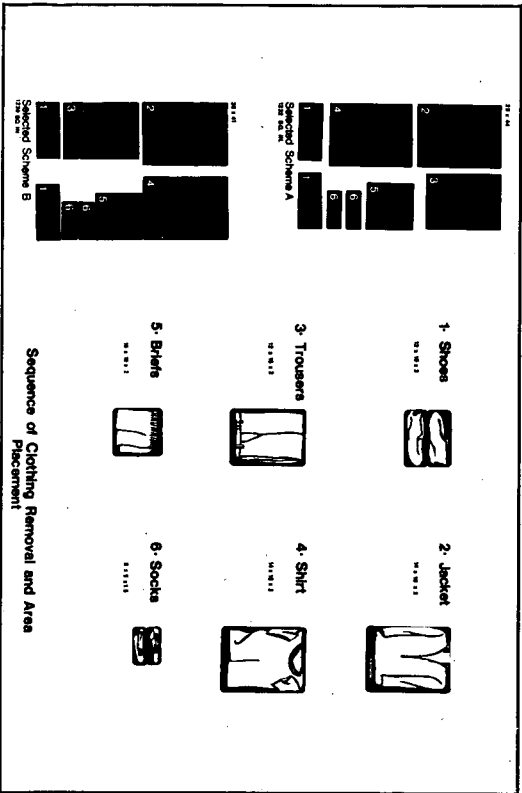
\*\* Figures from shuttle orbiter crew station habitability requirements study for flight personnel accommodations.

\* No change is foreseen in the garments for women. It is assumed that special supports would be sewn into existing undergarments.

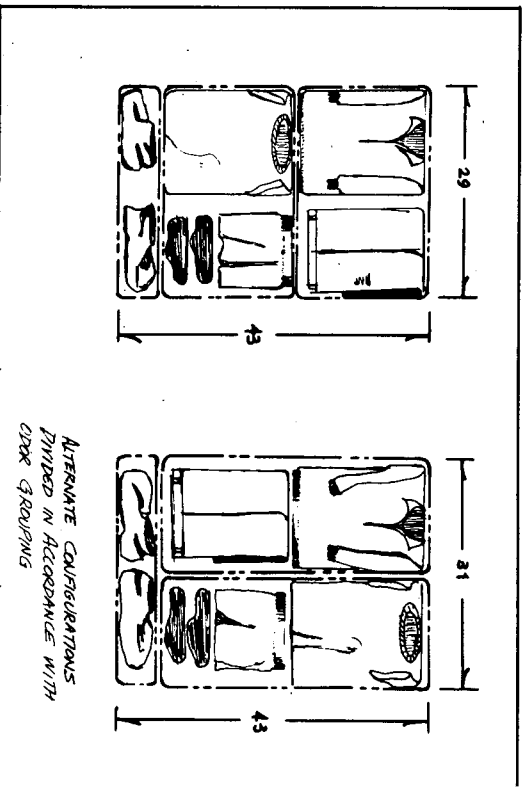
\*\* Figure does not include interfaces.

\*\*\* Figures from shuttle orbiter crew station habitability requirements study for flight personnel accommodations.

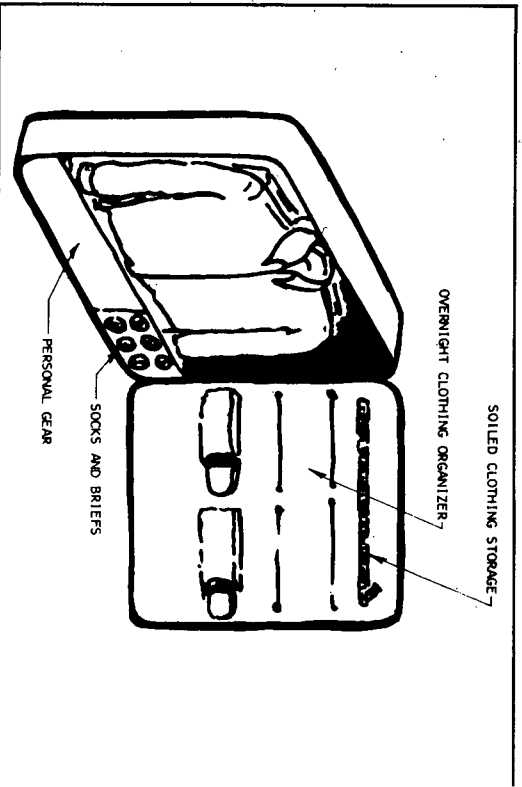
F1 Garment Restraint Study Guidelines



F2 Accepted Clothing Layout - Schematic



F3 Accepted Clothing Layout - Drawing



F4 MSC Existing Clothing Storage Concept

- 2 No odor separation between high and low odor producing garments.
- 3 Ventilation of air non-existent.
- 4 Not enough area available to store clothing neatly, wrinkle free.
- 5 Method of access and restraint, not demonstrated.

LOEWY/SNIATH  
APPROACH A  
FIGURES F5-F8

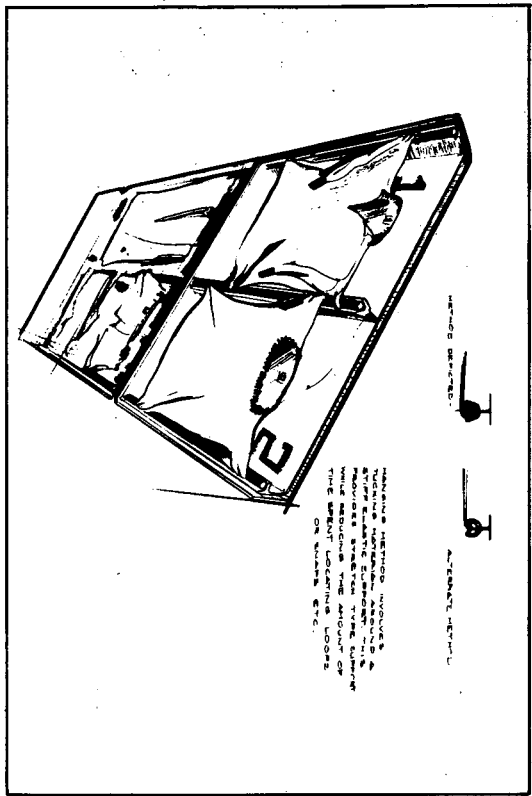
Partitioned Cavity Restraints

These schemes retain the clothing items within partitioned cavities. They maintain odor separation and clearly designate proper clothing placement. Wrap around stiff elastic supports (Figure F5), retain the garments in a wrinkle free state. Figure F6 utilizes individual tracked doors to visually clean up the appearance of the unit while enabling separate access to different order level compartments. Figure F7 utilizes parallel Bungee cords, which "give" to allow passage of garments into units, as is. Figure F8 retains clothing by fastening an air tight felon across the structure and over the clothing items. The unit folds in half when closed to minimize the wall area required for storage.

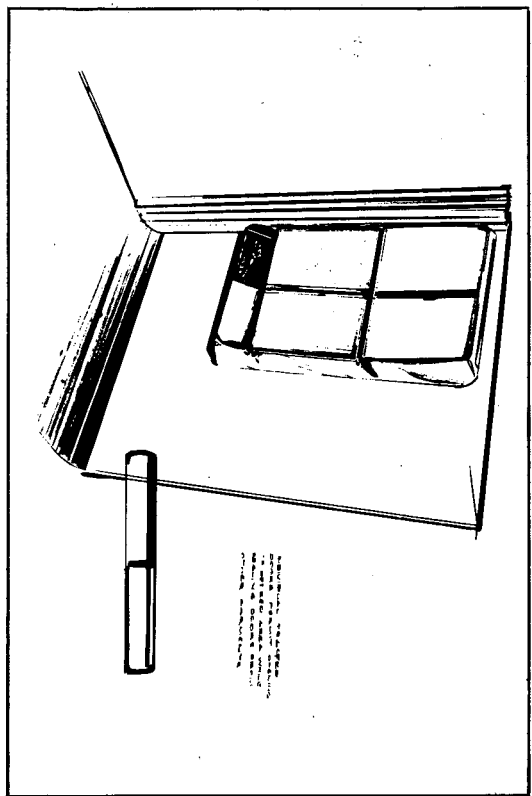
APPROACH B  
FIGURES F9-F12

Minimum Area Restraints

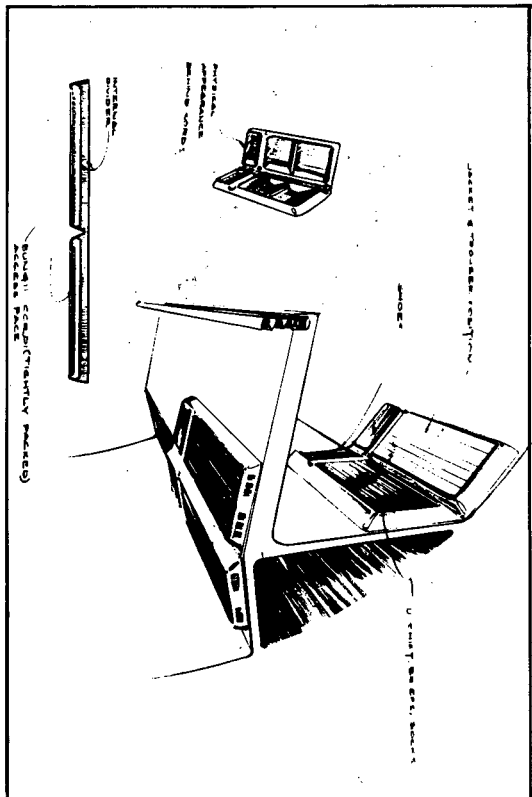
In Figure F9, a collapsible parallelogram type frame is used to minimize unit area requirement when not in use. To use the unit, the folded parallelogram frame is radially opened to form a rectangular frame. A roller shade curtain located in the par of the base arm, is pulled up into place and secured to prevent the rectangular frame from wrecking. This shade contains attach points for the appropriate clothing (high or low odor) items. Once clothing items are in place, a second roller shade, located in the front of the base, is pulled up into place to seal the unit.



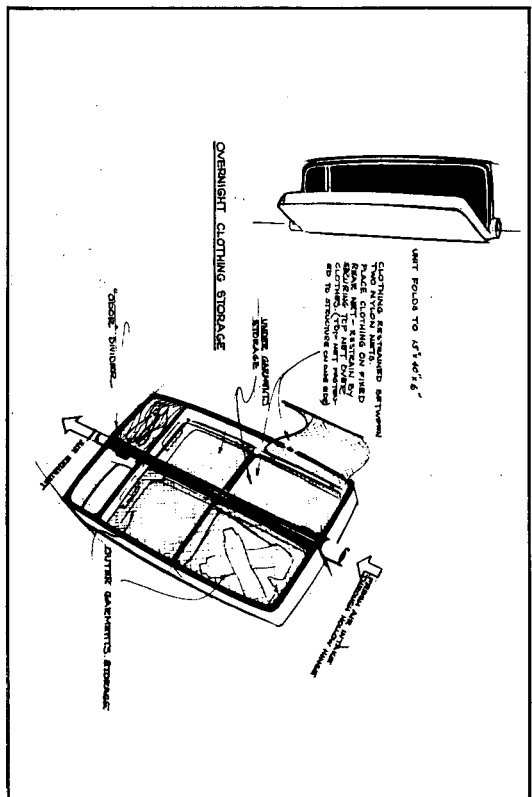
F5 Partitioned Cavity Restraint - Clothing Tucked Around Support



F6 Partitioned Cavity Restraint - Individual Article Compartment



F7 Partitioned Cavity Restraint - Bungie Cord Restrained



F8 Partitioned Cavity Restraint - Netting Restrained





In Figure F10, tubular frames fold into each other to produce a flat unit. When clothing is restrained, high odor items are pivoted to a down position, while lower odor items are restrained in the up position. An over covering is drawn to conceal the entire unit when in use.

Figure F11 is mounted under the couch, pivoted into front position for easy access. Again a tubular frame support is utilized within a partitioned structure. Fresh air enters the top. Figure F12 demonstrates the use of a half open continuous belt. Clothing items are restrained with Velcro placed strategically on the band and clothing. The belt, on which the clothing is restrained, when rotated, acts as the cover for the unit.

SECTION G	
TASK	Restraint System for Hygiene Facility (Phase II)
CENTER	MSC - Gordon Rysavy
DATE ASSIGNED	April 5, 1972
PARAMETERS	
1	Utilize the accepted "L" shaped hygiene compartment (Loewy/Snaith - MSC developed).
2	Fifty cubic feet is established as the accepted maneuvering space and clear volume within the hygiene facility.
3	Three points of restraint are necessary when using the fecal/urinal collector.
4	Degree of restraint should be the option of the individual.
5	Techniques of restraint should be simple.
6	Adaptable from 5% female to 95% male crewman.
TASK OBJECTIVES	MSC requested that additional work be directed at the development of the elbow restraint system. Specifically, the study was to examine the problem of adapting the system to personnel from 5% female to 95% male. Adjustments, if necessary, should be accomplished without utilizing mechanical devices.

## SCHEDULE

A final presentation was scheduled for May 31, 1972.

ANALYSIS OF  
EXISTING APPROACH

Lap Belt Restraint

- 1 Exposed skin areas contacting belt is considered undesirable.
- 2 Attachment points interfere with wipe motions.
- 3 Belt and related mechanism may soil easily and prove difficult to clean.

Elbow Restraint

The elbow restraint, being an active one, requires the conscious awareness by the crew personnel as it is being used. Temporary periods of pain or illness may make a back up positive restraint system necessary.

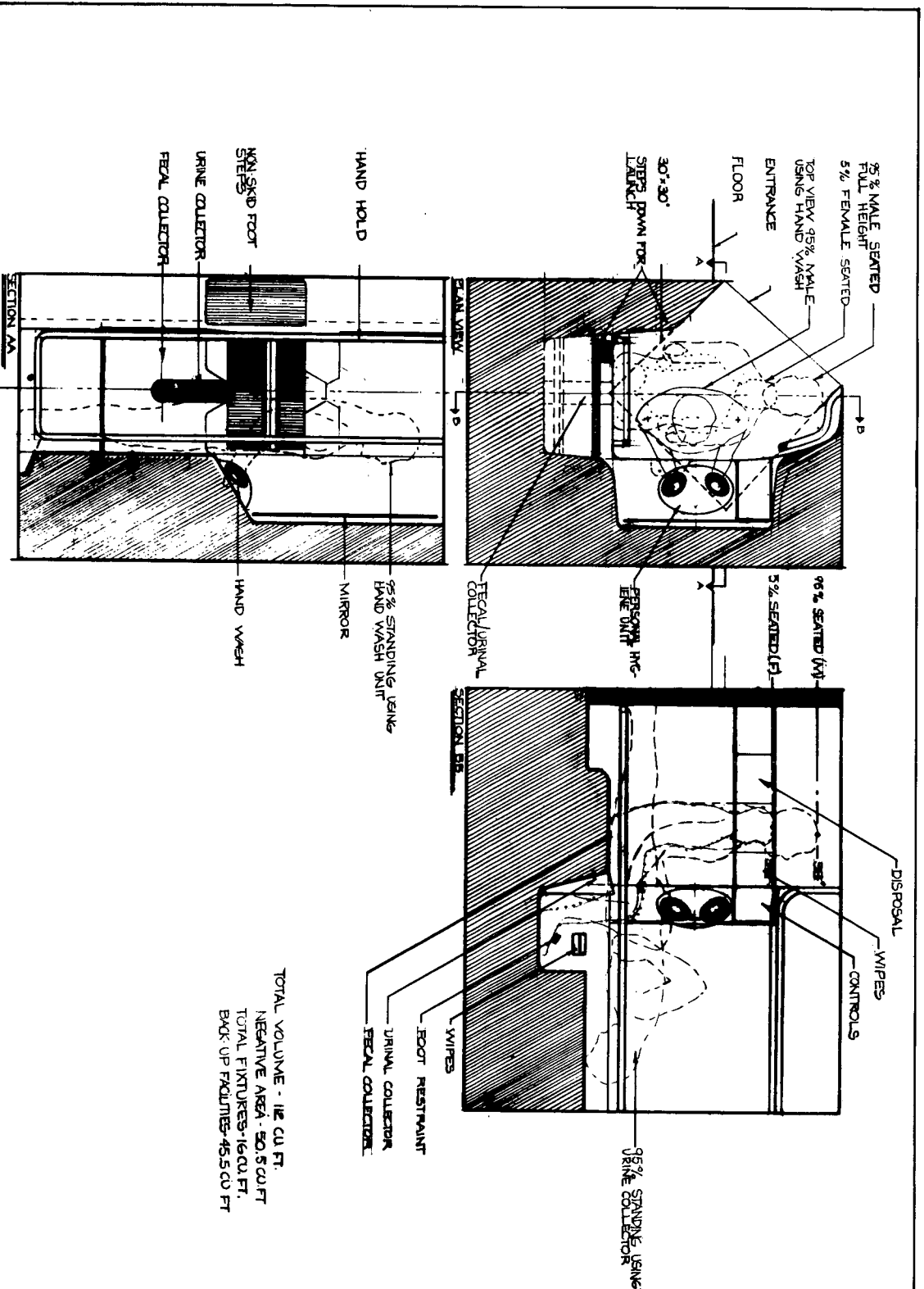
LOEWY/SNAITH

APPROACH

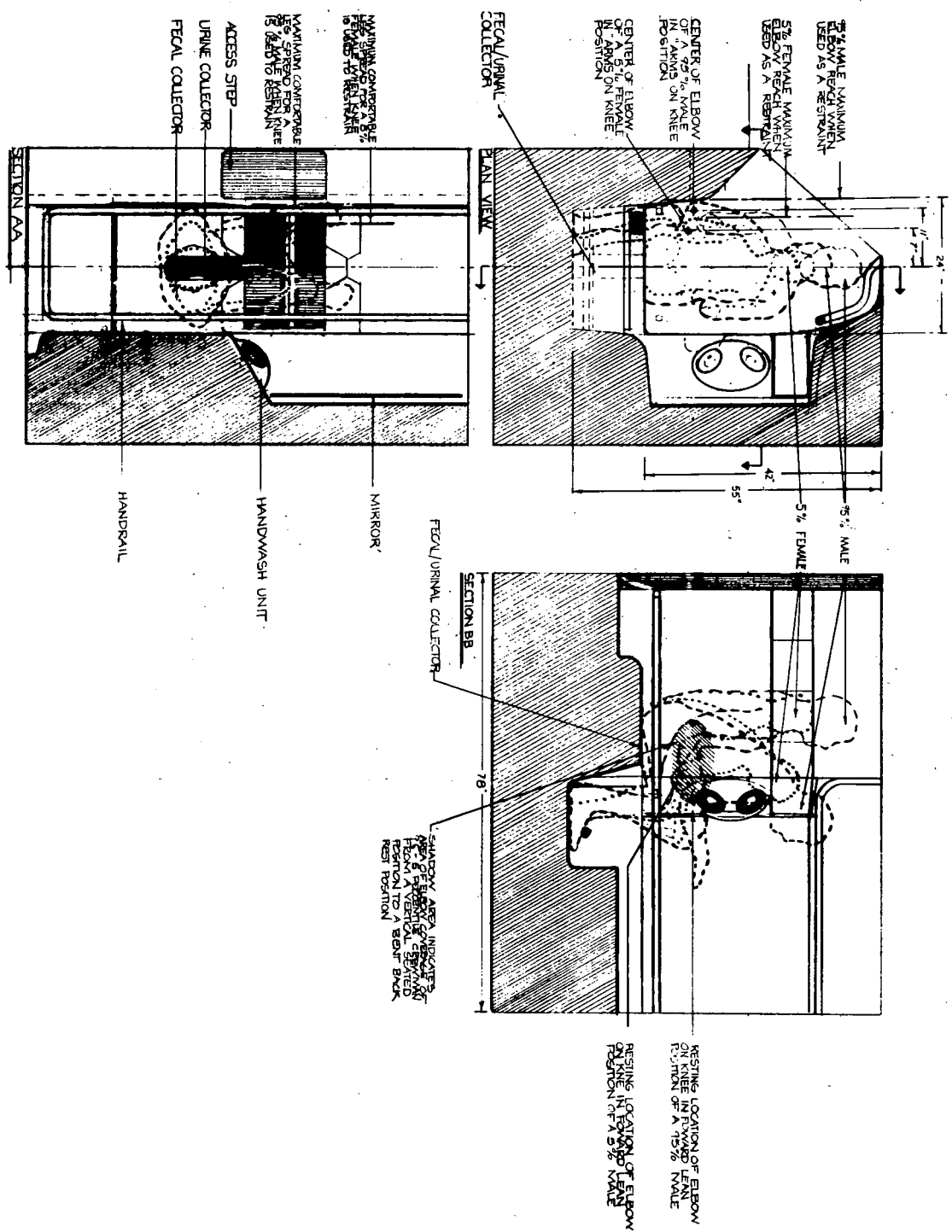
FIGURE G1-G2

Phase II Variations in the Hygiene Compartment Configuration

- 1 The hand-wash unit previously configured with frontal access has been modified to receive a spherical acrylic bubble with individual hand holes in the top front. The total height of the unit has been decreased enabling an individual seated on the fecal collector to use the unit more easily.
- 2 Lateral head clearance has been increased over the fecal collector. The previously peaked vertical height, diagonally opposite the slinger, has been squared.



G1 - Waste Management Area of the Shuttle Orbiter - Phase II Variation



G2 - Waste Management Area of the Shuttle Orbiter - 5% Female to 95% Male Elbow and Knee Locations

#### Elbow Restraint (Figure G3-G8)

The results of the Phase I study of the hygiene compartment created interest in developmental possibilities of an elbow restraint. Phase II of the hygiene restraint study tested the feasibility of an active elbow restraint.

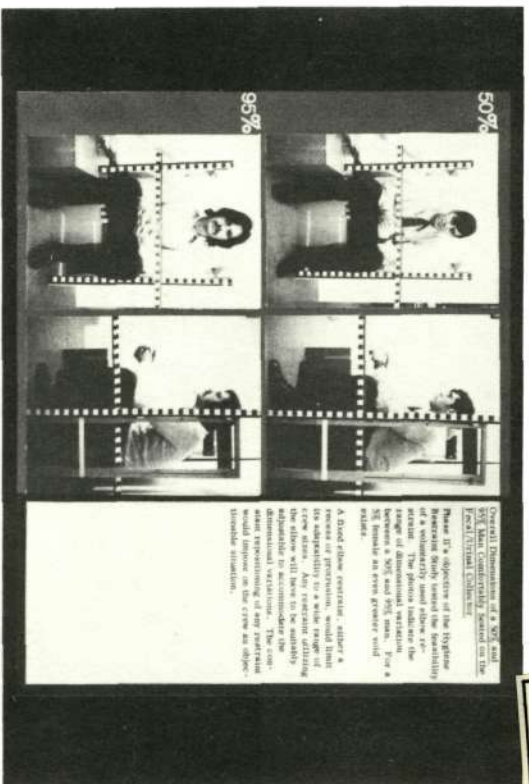
Tests conducted with a wide range of body sizes indicated that a stationary recess deep enough to accommodate a 95% male would be unduly large for a 5% female. To adapt to a smaller individual a mechanical device would be necessary to decrease the hygiene compartments wall width. The constant repositioning of any restraint would impose on the crew an objectionable situation, and create potentially unhygienic undercuts and recesses.

Because the extent of protrusion varies substantially between crewmen, a stationary elbow restraint appears unfeasible and impracticable.

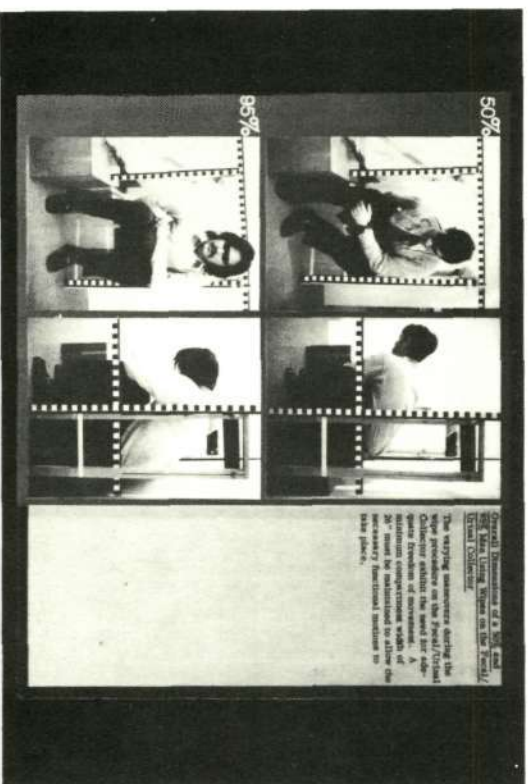
#### Lap Restraint (Figure G9-G16)

As generally noted in the past, the lap restraint has many ingenious qualities which tend to overshadow its positive attributes. The hygiene compartment, a communally used facility, has fixtures with which more than one crewman will have skin contact. The psychological disturbance in the knowledge that an object has had contact with the eliminating areas of another body, is one which requires consideration.

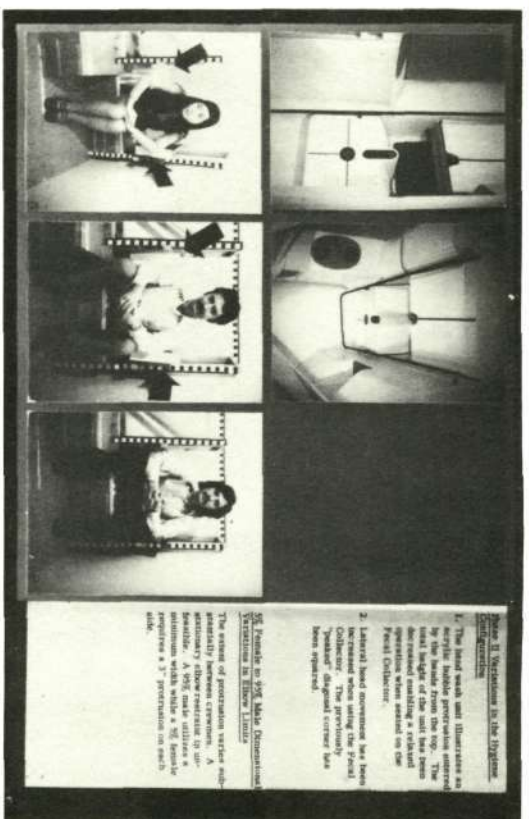
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G3 - Dimensions of Seated Personnel - 50% and 95% Male



G4 - Dimensions of Seated Personnel Using Wipes. 50% and 95% Male

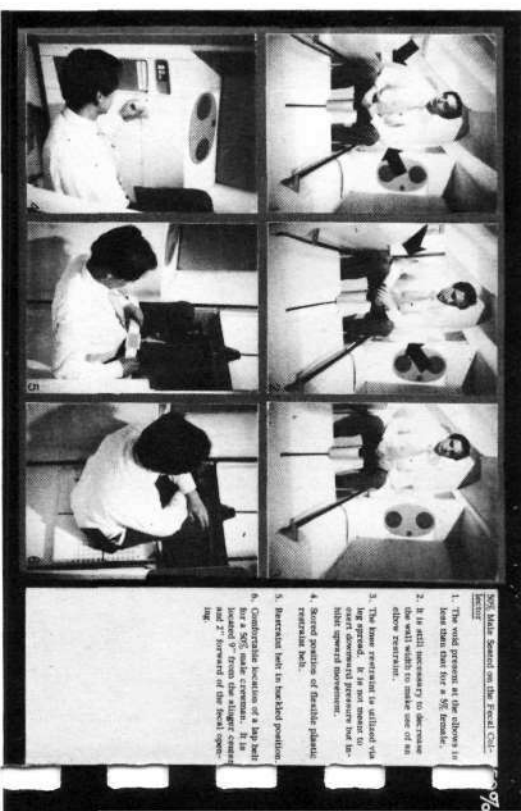


G5 - Compartment Variations and Dimensional Elbow Limits

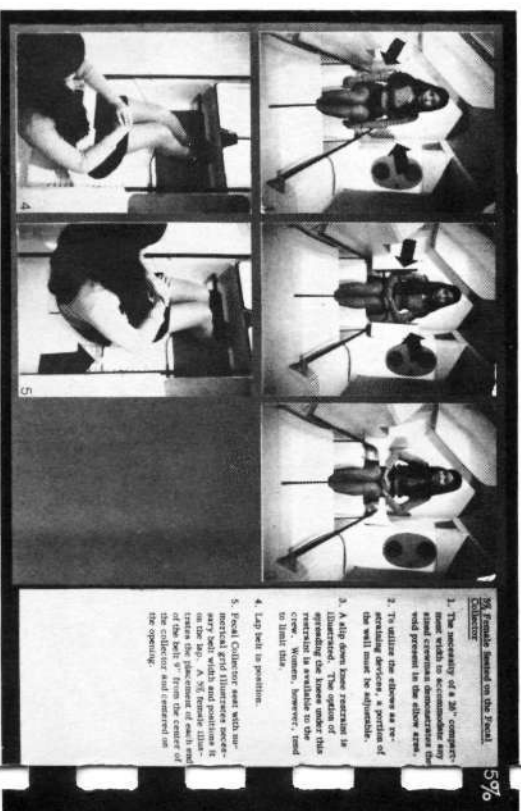


G6 - 95% Male Pictorial Study

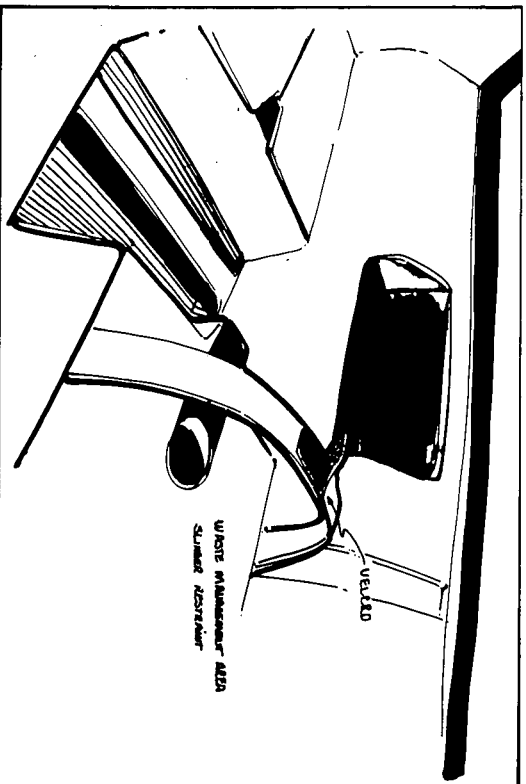




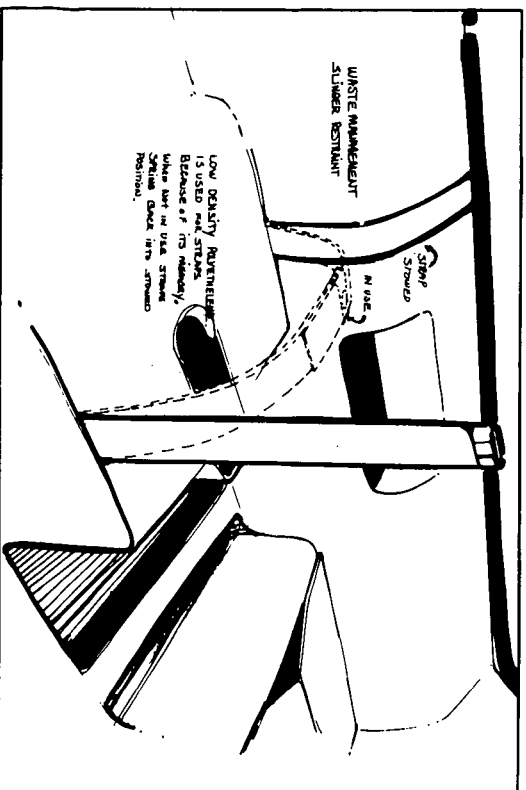
G7 - 50% Male Pictorial Study



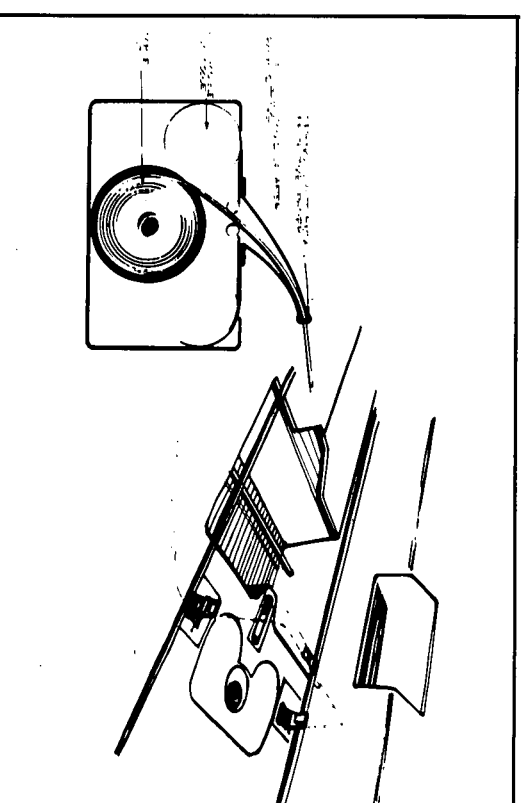
G8 - 50% Female Pictorial Study



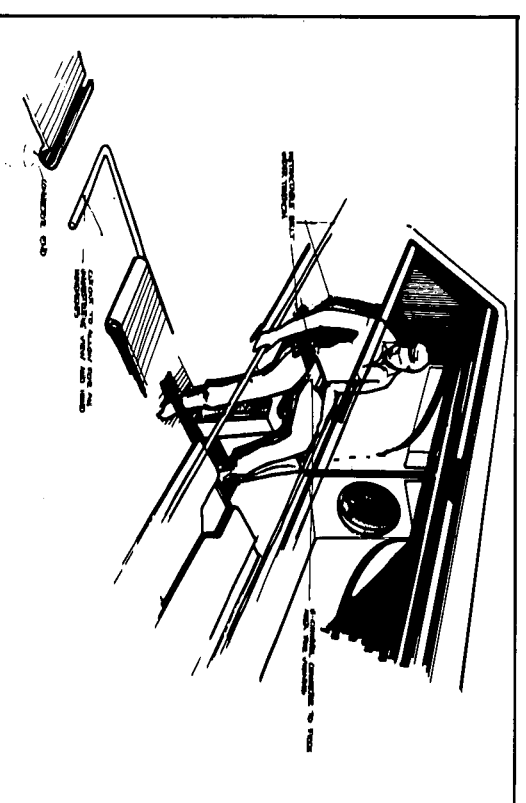
G9 - Semi-Rigid Belt Restraint with Velcro Fastener



G10 - Semi-Rigid Belt with Coupler Fastener



G11 - Tissue-Backed Inertia Reel Belt



G12 - Restraint Belt with Minimum Coupler Surface Area

A black and white line drawing of a person lying on their back, holding a long, thin object (possibly a cigarette or pen) in their mouth. The person is wearing a light-colored shirt and dark pants. The drawing is simple and sketchy, with some text written vertically on the left side.

RESERVANT IS INCORPORATED  
INTO TROUBLE, PROVIDING  
THE ULTIMATE IN PERSONAL-  
IZATION WITHOUT UNDESIR-  
ABLE DUPLICATION OF PARTS.

SEMI-RIGID RESTRAINT  
DIRECTS PELVIS TO  
PROPER POSITION

## G16 - Flexible Rear-Mounted Restraint

The degree of skin contact, while using the hygiene compartment, varies with each unit. An option should be present as to the extent of personal body isolation a crewman desires within the facility. The availability of "tear-off" tissue as a means of isolating body contact is proposed in several of the concepts. It enables each crewman to select the degree of utilization. One illustrates a retractable belt which when drawn captures a tissue roll top and bottom as it is being drawn to the center. After use, the tissue is disposed of. Another positions pads under the restraint where it comes in contact with skin. These are not part of the restraint, but placed by the crewman.

Flexible non-porous material, such as styrene requires little maintenance and can be easily cleaned when soiled. It can be pre-formed to automatically relocate in an upright position when not in use. The amount of tension is controlled by the user. The belt may be only used when conscious restraint is not practical, such as during periods when an individual is experiencing cramps.

The photo series of 5% female - 95% male crewmen seated on the fecal collector using the belt restraint indicates the different body widths. Although there is a difference, a comfortable seated dimension never varied more than two-inches from the center of the slinger. A restraint shift of this amount would be negligible. But by utilizing the hand rails on each side of the collector as guide rails, these adjustments could be accomplished.

Information gathered from the restraint study reinforces the utilization of a lap restraint. Observations include:

## STUDY ANALYSIS

1

Three points of restraint (defined by Martin Neutral Buoyancy Study):

- a. Foot restraint (2).

- b. Lap belt: when manual restraint is not possible or desirable.
  - c. Hands: guide rails properly placed may suffice and, in fact, be preferred over lap belt restraint.
- 2 An option of personal isolation from communally used units may be desirable - disposable restraint cover tissues.
  - 3 The degree of tension should be left up to the individual.
  - 4 The extent of restraint mobility should be kept minimal because of its limited effects.

RELEASE BUTTON

RETRACTABLE PART MUST BE USED TO RELEASE THE BOMB

## G18 - Moveable Inertia Reel Restraint Utilizing Guide Rails

SECTION  
H

## TASK

Skewed Z-Axis Dock/Airlock System Shuttle Orbiter 1/20 Scale Model

## DATE ASSIGNED

April 5, 1972

## PARAMETERS

- 1 Utilize the skewed Z-axis dock/airlock system in a shuttle orbiter configuration.
- 2 Maintain present positioning for the reaction control system, equipment bay and wheel well.
- 3 Accommodate six men for seven days.
- 4 Hygiene and galley unit positioned on same side of the orbiter with common wall surface.
- 5 Reaction control system restricted to nose location.

## TASK OBJECTIVES

Analyze the existing approach and develop recommendations to improve the overall habitability of the crew compartment.

## SCHEDULE

The final presentation of the 1/20 scale nose model of the shuttle orbiter was scheduled for May 31, 1972.

ANALYSIS OF  
EXISTING APPROACH  
FIGURE H1

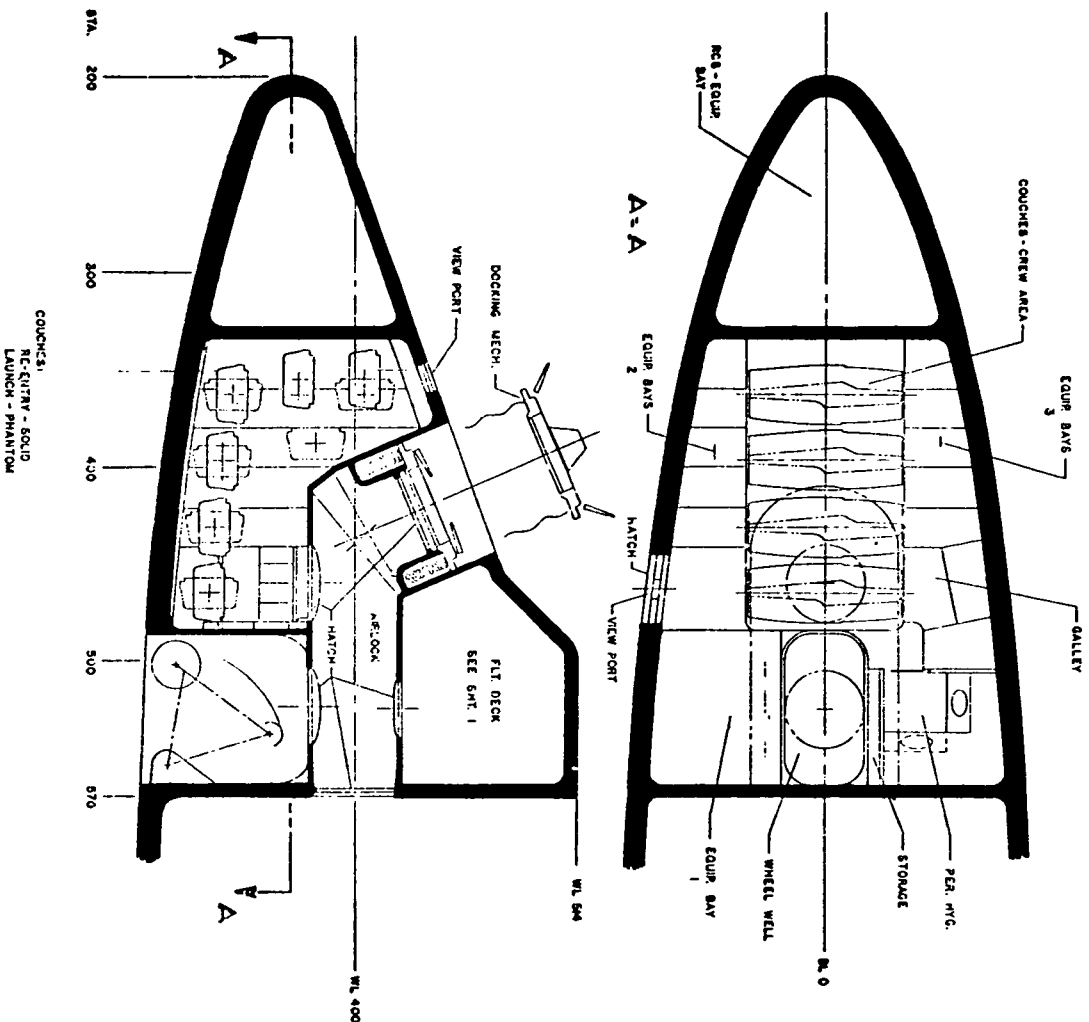
- 1 Access to the hygiene compartment is extremely difficult; no steps exist within the unit.
- 2 Airtlock protrudes into the present position of the galley interfering with the head movements of the attendant.
- 3 The accessibility of the hygiene compartment to all occupied couches in launch orientation is limited.
- 4 The unchecked vertical drop from the top couch to the rear bulkhead in the passenger compartment could create a dangerous pre-launch situation.

LOEWY/SNAITH  
APPROACH  
FIGURE H2-H6

Hygiene Compartment

The possibility of launch pad delays necessitate pre-launch access to the hygiene compartment. A ladder, convenient to the four launch occupied couches, can be used to descend into the hygiene compartment. To facilitate entry into the compartment in all modes of operation, a large two-section tambour door is utilized. Steps are located in the walls to enable the crewman to mount the fecal collector safely in the pre-launch mode.

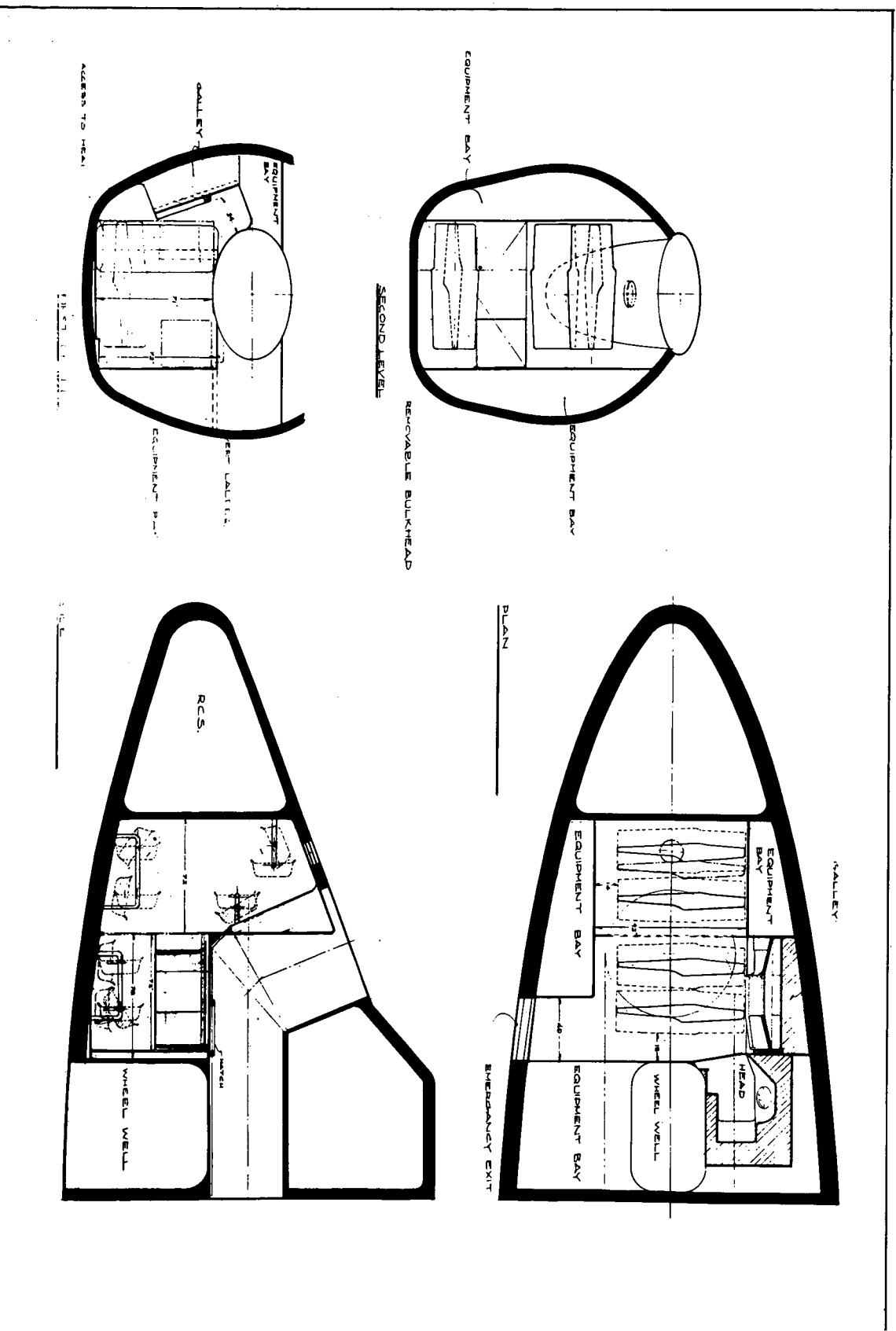




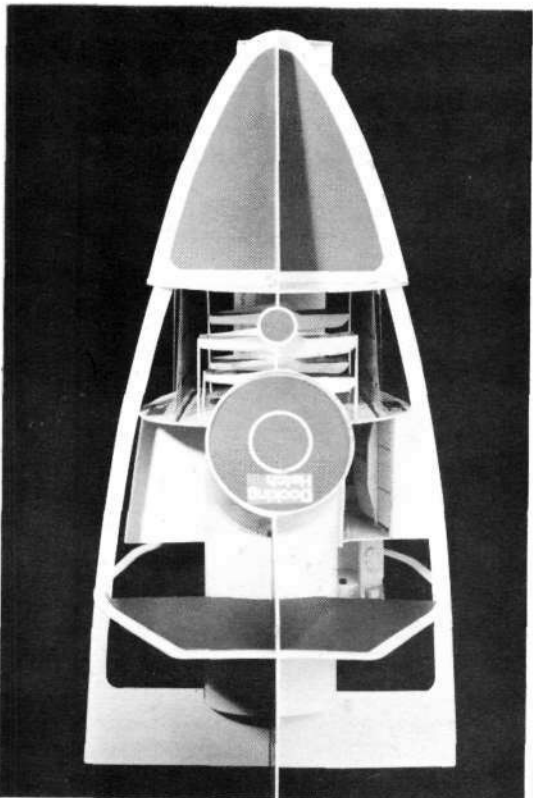
VOLUMETRIC ALLOCATION :

AREA	VOL. - CU. FT.
PER. MFG.	150
GALLEY/HOUSEKEEPING	100
COUCHES	150
CREW AREA/PASSAGEWAY	300
EQUIP BAYS	350
WHEEL WELL	150
DOCKING MECH.	150
STORAGE	200
TOTAL	2400

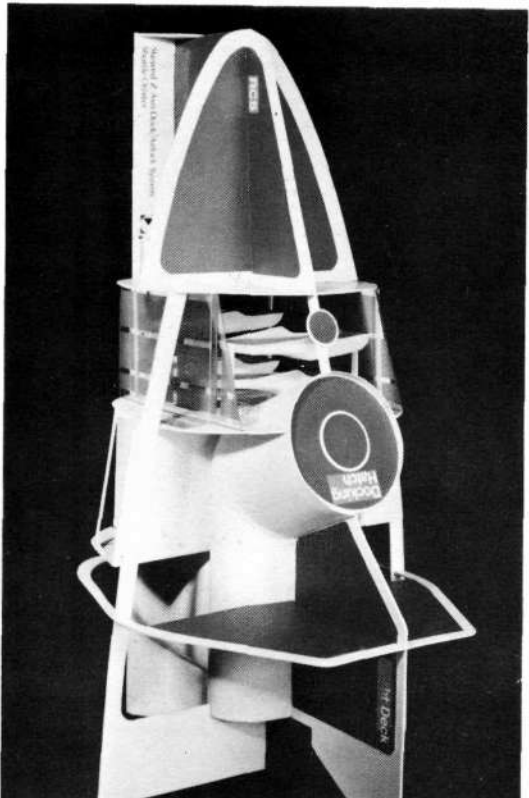
H1 - Existing MSC Skewed Z-Axis Docking/Airlock System



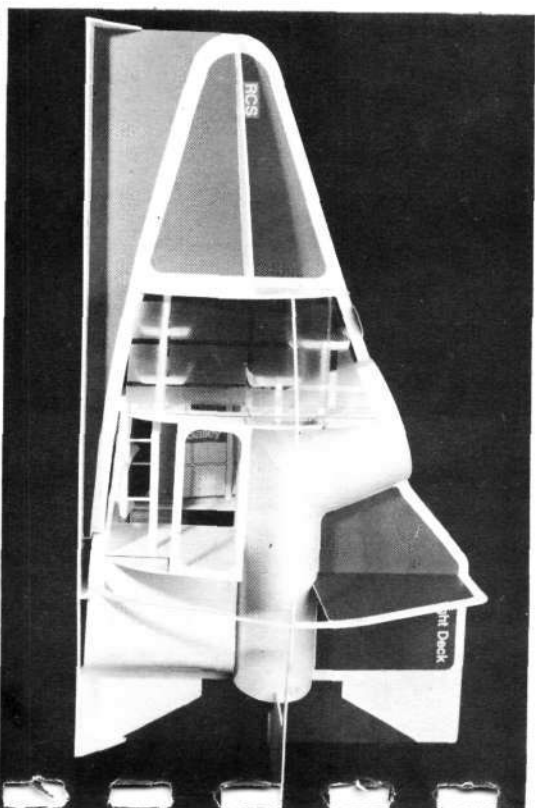
H2 - Loewy/Snaith Proposed Skewed Z-Axis Docking/Airlock System



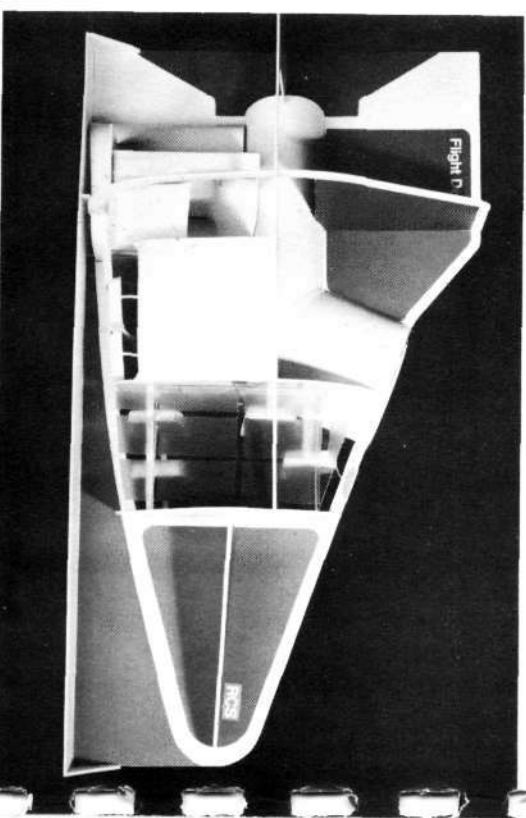
H3 - Top View of Shuttle Orbiter Scale Model



H4 - Perspective View of Shuttle Orbiter Scale Model



H5 - Shuttle Orbiter Scale Model - Viewing Galley Through Emergency Escape Hatch



H6 - Shuttle Orbiter Scale Model - Viewing Back Side of Galley and Head

### Food Management

In the original layout, the entrance to the hygiene compartment is obstructed by the attendant during meal preparation. The airlock protrudes into this standing volume so that it tends to limit the attendant's head movements. To eliminate these interferences, the food management unit has been rotated 90 degrees orienting the top toward the nose of the orbiter. The hygiene entrance is now at the attendant's feet and his maneuvering room has been greatly increased.

### Passenger Compartment

To prevent the possibility of a long dangerous fall from the top space couch during the pre-launch period, a removable bulkhead has been installed between the second and third couch. This does not limit passage or communication through the compartment and is stored during Zero-G and re-entry flight.

The space couches have been mounted on support columns which enable them to be reoriented during the various flight modes. This feature permits the couches to be located close to the deck during Zero-G periods, creating a large pass through area.

SECTION  
1

TASK Positive Flexible Restraints (Phase I)

CENTER MSC - Gordon Rysavy

DATE ASSIGNED May, 1972

PARAMETERS

- 1 Positive restraint to be used during relatively long periods of time (15 minutes or more).
- 2 Operational with a minimum of effort.
- 3 Adaptable to a variety of work stations, displays and surfaces.
- 4 Restraint flexibility to allow limited controlled movement.

TASK OBJECTIVES

The development of a positive flexible restraint is being pursued in order to free the crewman of conscious awareness of the necessity for restraint, and allow him to concentrate fully on his particular task. Unlike existing waist restraints, the restraints studied should be adaptable enough to conform to the individual's physical maneuvering patterns during the tasks assignments.

ANALYSIS OF  
EXISTING CONCEPT

Flexible restraint concepts were developed in early work bench studies to allow for lateral or radial movement.

Comments (Figure 11)

## Favorable:

- 1 Latitude of shift right to left.
- 2 Capability of adjustments for different sized individuals.
- 3 Tension adjustable.

## Unfavorable:

- 1 Difficulty of ingress and egress.

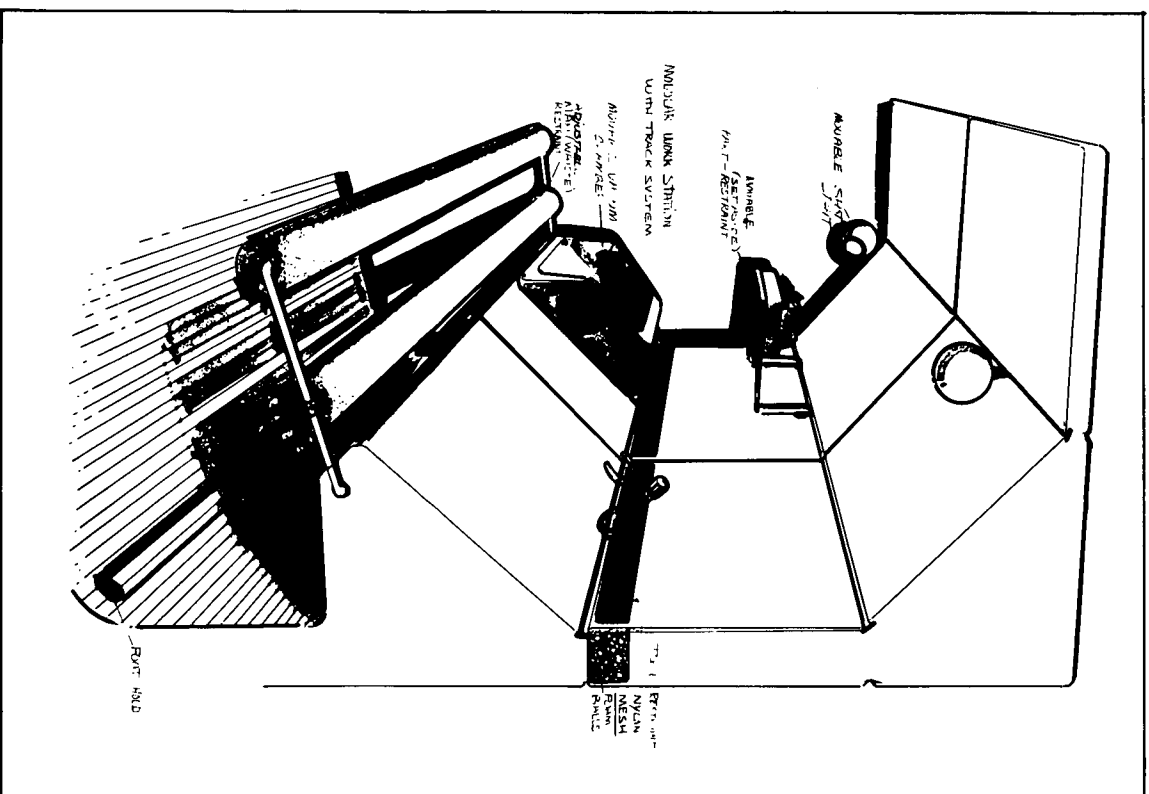
Comments (Figure 12)

## Favorable:

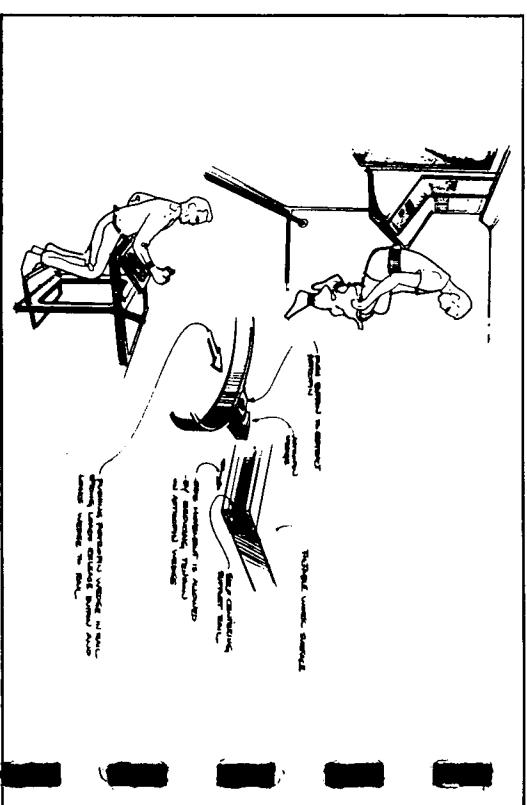
- 1 Ease of ingress and egress.
- 2 Lateral movement allowed.
- 3 Adaptable to all individuals.
- 4 With no adjustment required on sight (work station, etc.).

## Unfavorable:

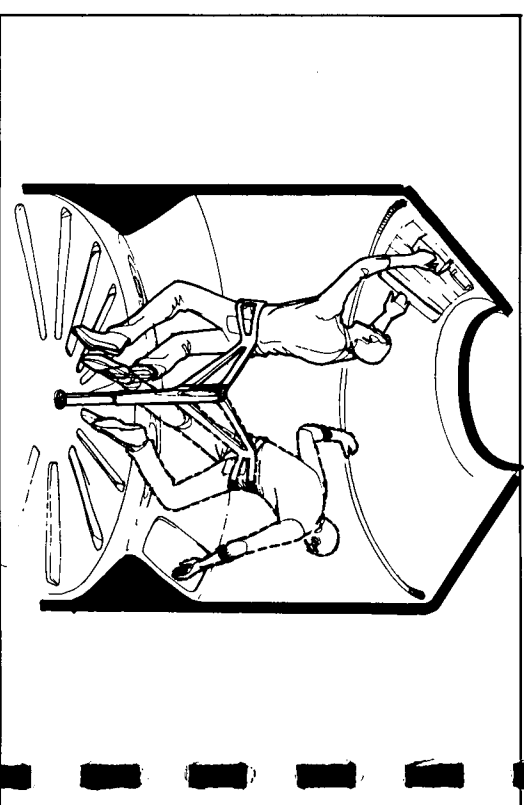
- 1 No vertical adjustment provided.
- 2 No fore/aft adjustment provided.



I-1 - Preliminary Concept for Adjustable Thigh Restraint



I-2 - Preliminary Concept Using Belt on Adjustable Guide Rail



I-3 - Preliminary Concept of Radial Restraint

Comments (Figure 13)

Favorable:

- 1 Vertical movement allowed.
- 2 Hands free movement allowed.

Unfavorable:

- 1 Lateral movement limited to radial pattern.
- 2 Requires excess amount of space.

Comments (Figure 14)

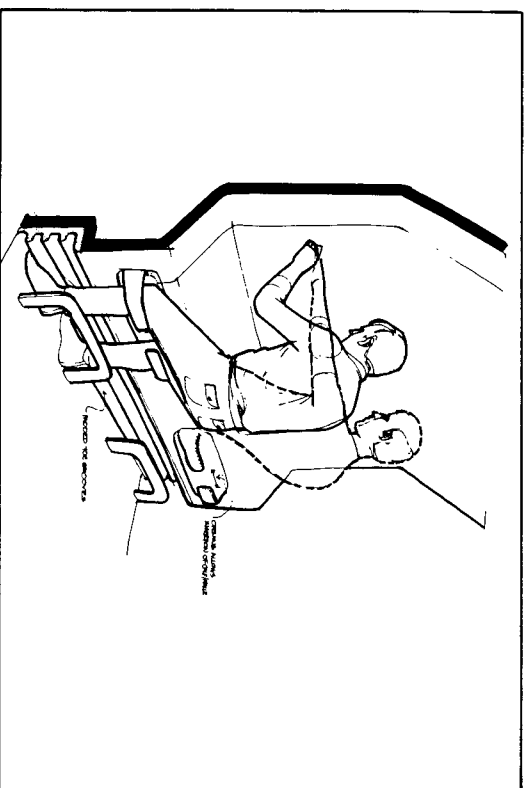
Favorable:

- 1 Vertical adjustments possible.
- 2 Restrained positively.

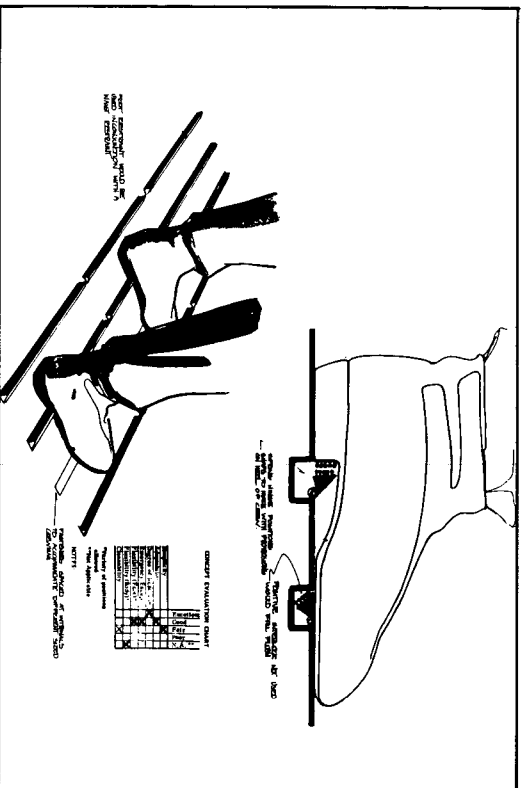
Unfavorable:

- 1 Lateral movement restricted.
- 2 Pressure behind knees.
- 3 Difficult ingress and egress.

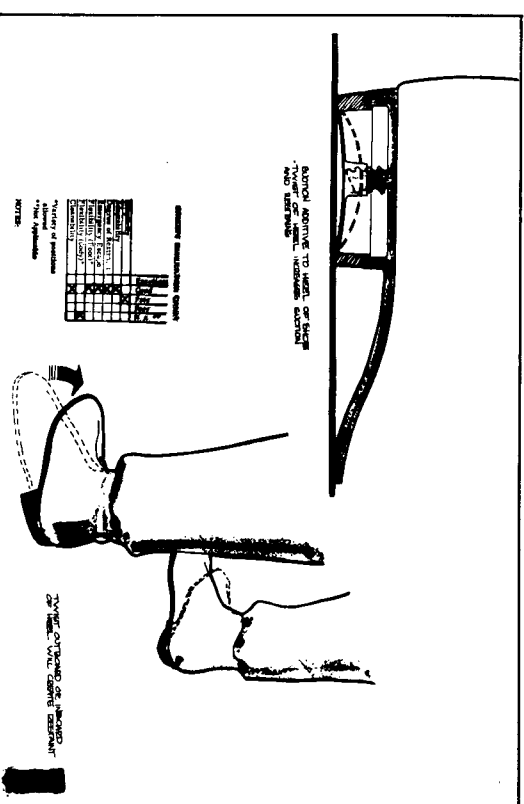




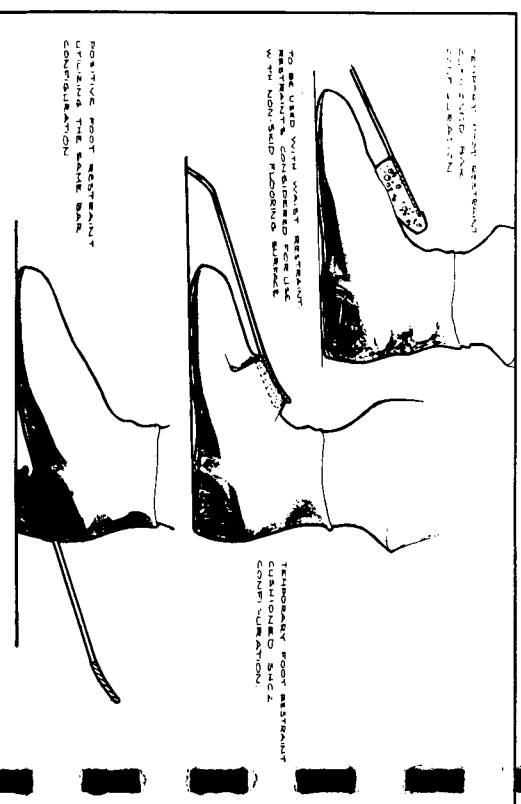
I-4 - Preliminary Concept of Positive Restraint



I-5 - Reconfigured Heel Snaps into Floor Mounted Fasteners



I-6 - Heel Mounted Suction Restraint



I-7 - Cushioned Bar Restraint

## OUR APPROACH

### Foot Wear Reconfiguration (Figures 15 - 17)

In several concepts, portions of the shoe has been reconfigured to improve its effectiveness as a restraint assist. We feel that when not in the area of a work station, the foot wear should not interfere with normal movement. Restraint concepts shown in Figures 15 - 17 require various degrees of interface equipment or surface preparation (16 requires a smooth non-porous surface). One common denominator is that in all cases the shoe under the ball of the foot has not been altered, thus allowing it to be used as a high friction surface for pushing off or maneuvering assistance during movement.

### High Friction or Interlocking Restraint (Figure 18)

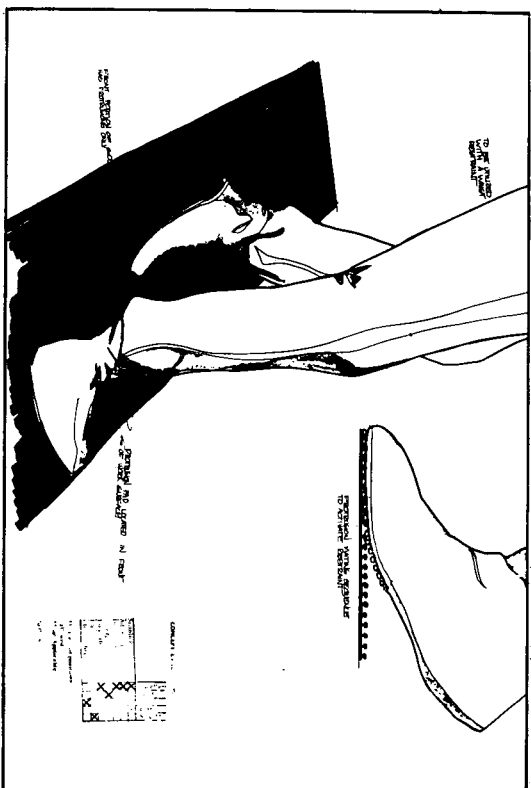
This concept depends on abrasive or interlocking surfaces. The foot wear, usually the sole portion because of its use in maneuvering and control by the crewman, has half of the restraint surface imbedded or applied to its surface. The other half could be placed in front of the work surface over a large enough area to provide the user a choice of foot location possibilities.

### Waist Mounted Restraints (Figures 19 - 115)

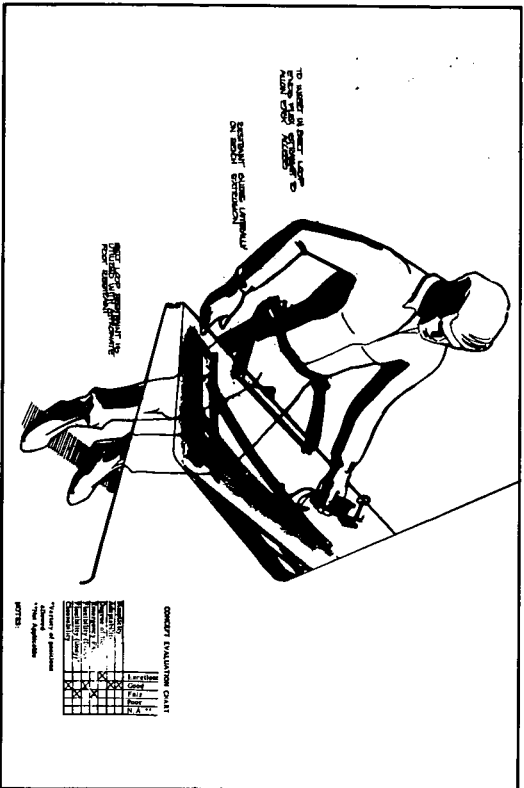
The proximity of the front edge of the work surface to the user's waist makes it a prime candidate for a waist restraint support. To provide for control restrained movement, a variety of restraint devices were explored utilizing mechanical slide and reel type systems.

### Wedge Restraints (Figures 116 - 119)

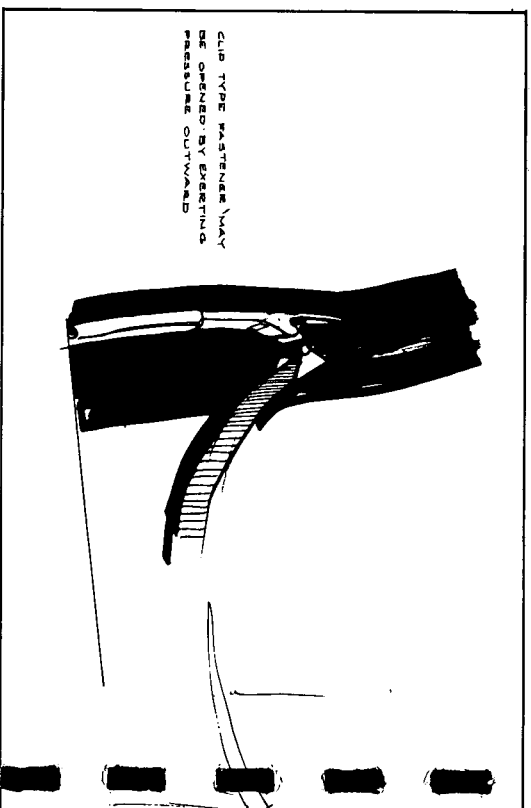
These concepts rely on positioning of the foot in undercuts to properly restrain an individual. Located at intervals at the base of the work station, the crew has a multitude of foot placements available. Either integrated with the deck or add-ons, these concepts insure positive restraint while allowing flexibility in which the individual may require to perform his activity.



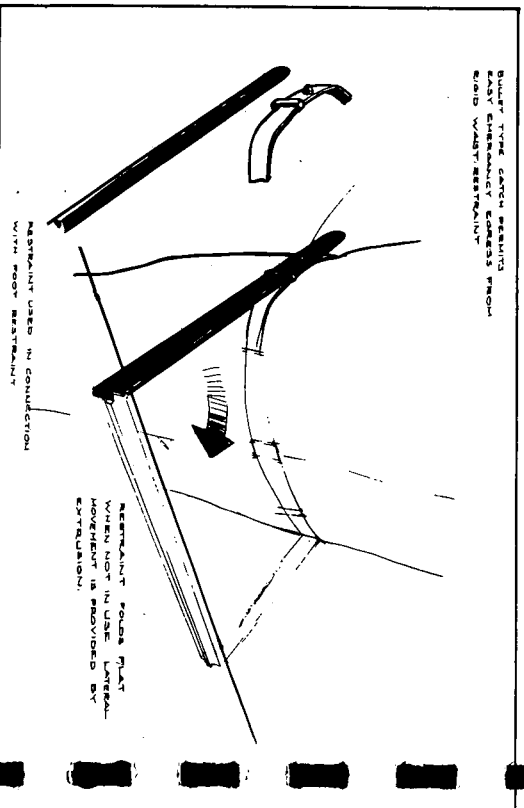
I-8 - Mating Protrusion Devices on Sole of Shoe



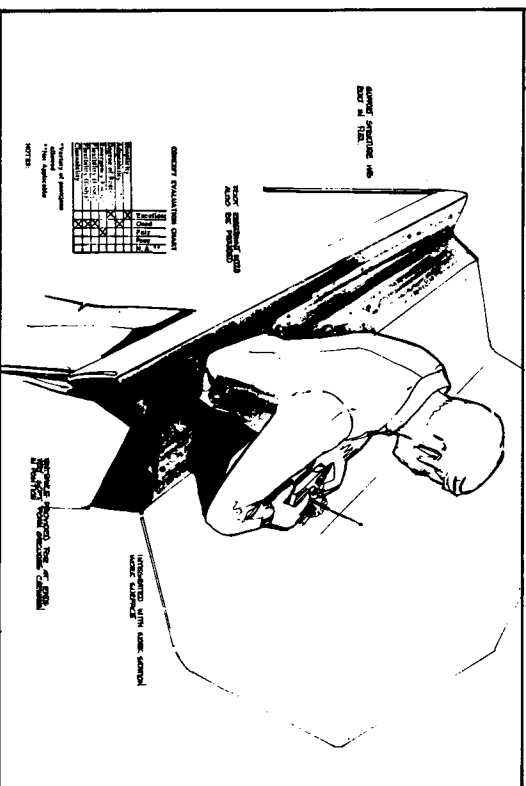
I-9 - Sliding Arms Interfacing with Belt Loops



I-10 - Detail of Clip-Type Fastener on Sliding Arm



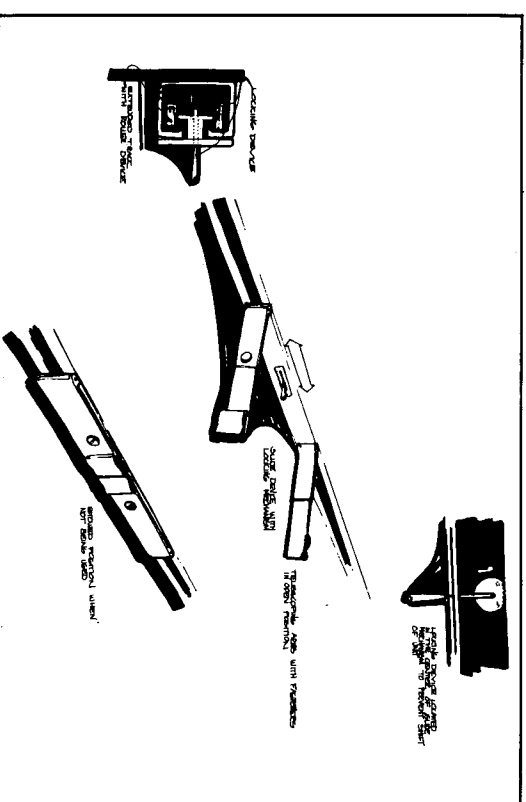
I-11 - Detail of Belt Mounted Bullet with Hole on Sliding Arm



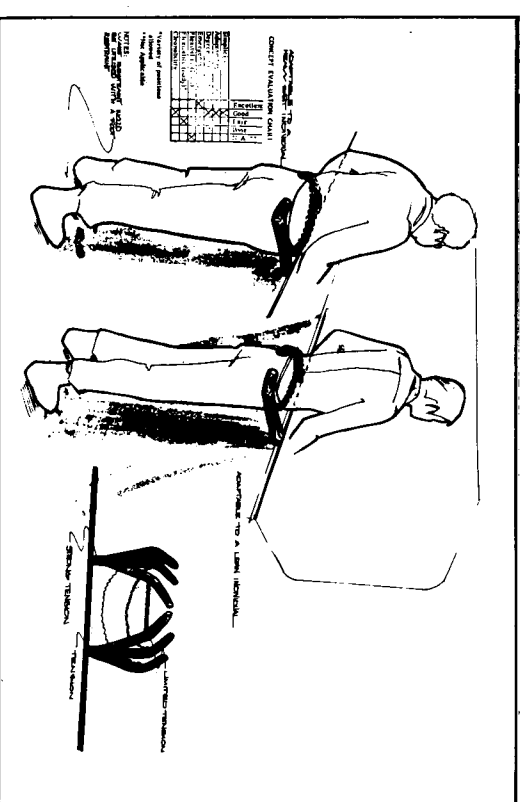
I-12 - Waist Restraint with Foam Mounted Tension Device



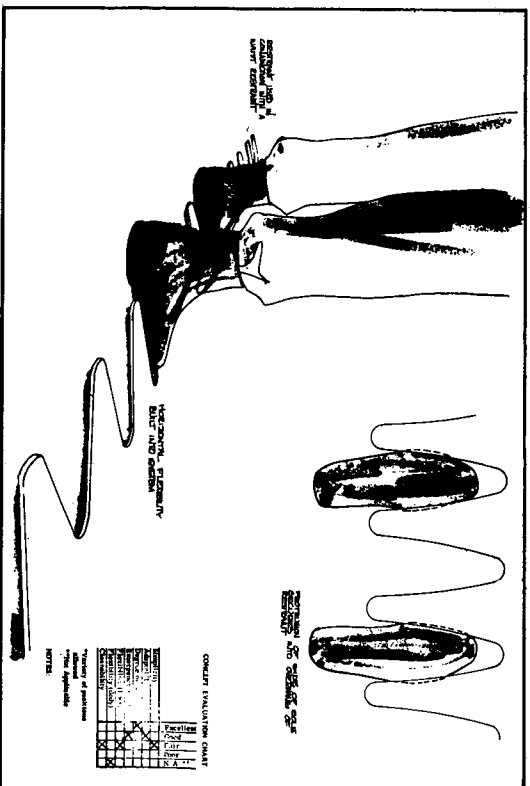
I-13 - Continuous Revolving Belt as Waist Restraint with Velcro Mating Surfaces as a Foot Restraint



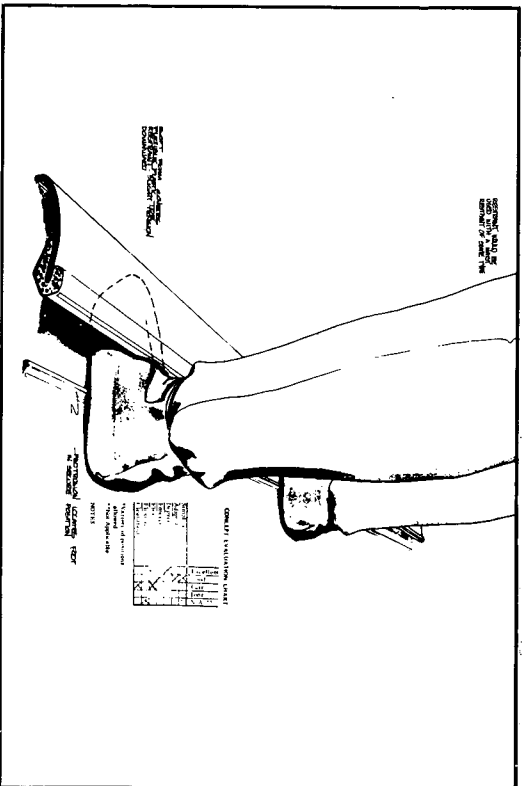
I-14 - Schematic of Telescopic Fold Away Arms with Locking Mechanism



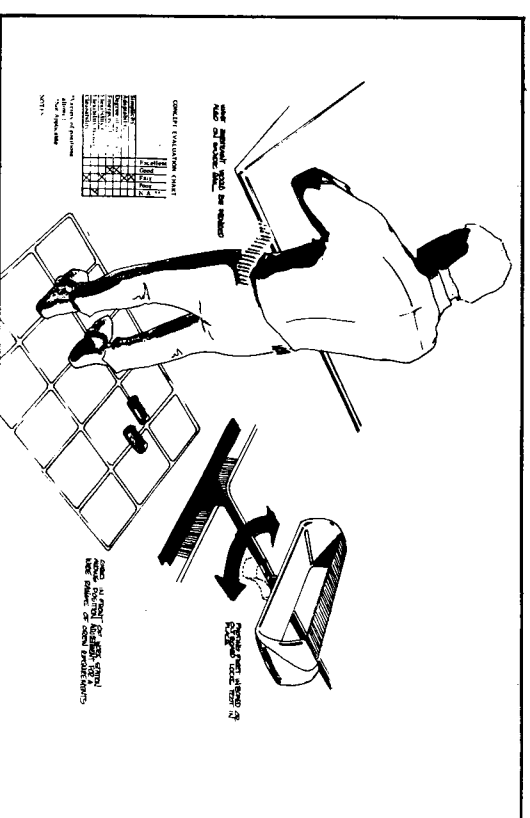
I-15 - Adjustability of Slide Mounting Arm



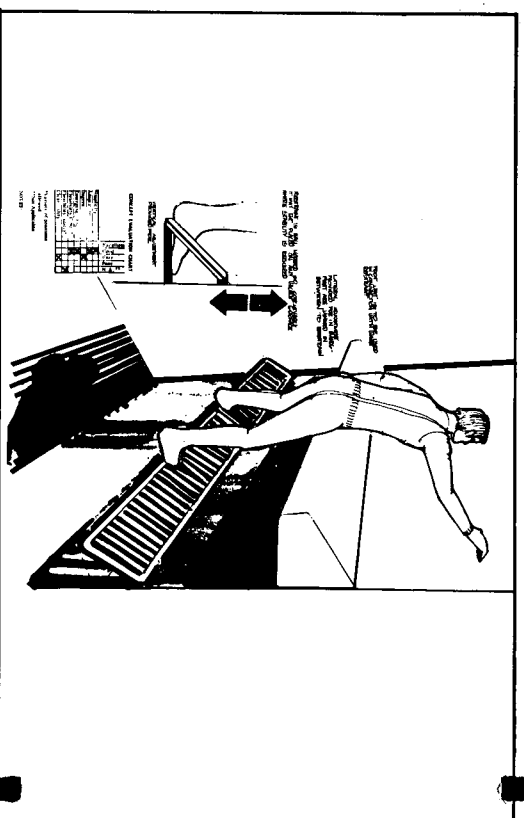
I-16 - Undercuts to Accept Enlarged Shoe Soles



I-17 - Foot Restraint with Foam Pad and Tension Adjustment



I-18 - Foot Sleeves with Guide Channel



I-19 - Flexible Tension Members with Height and Vertical Adjustment

SECTION  
J

TASK Positive Restraints (Phase II)

CENTER MSC - Gordon Rysavy

DATE ASSIGNED July, 1972

## PARAMETERS

- 1 Positive restraint to be used during relatively long periods of time (15 minutes or more).
- 2 Operational with a minimum of effort.
- 3 Adaptable to a variety of work stations, displays and surfaces.
- 4 Restraint flexibility to allow limited controlled movement.

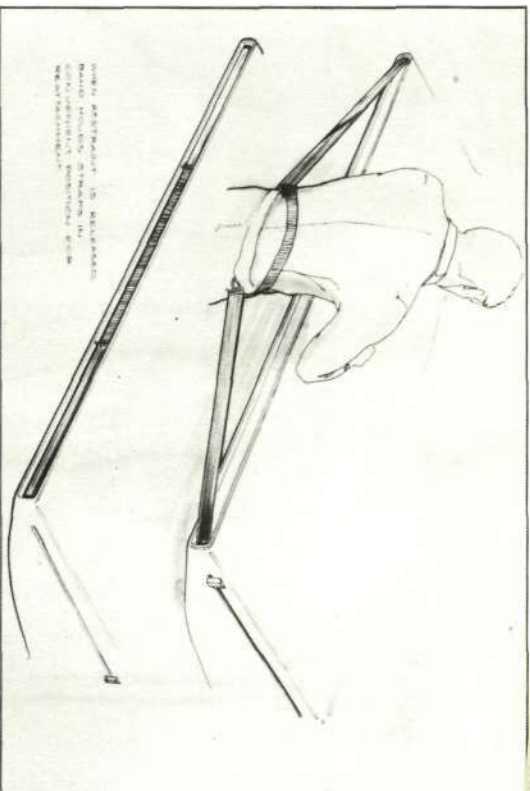
TASK OBJECTIVES Develop test mock-ups of selected concepts illustrated in Section I.

## APPROACH A

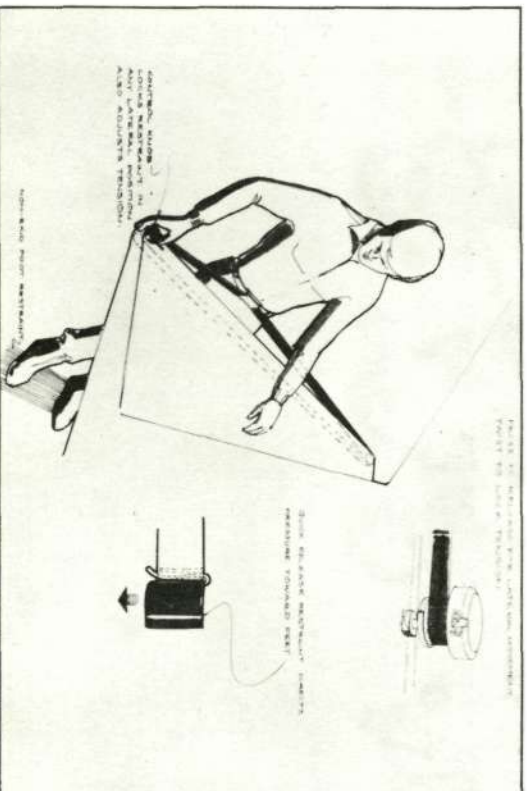
Figures J1 - J4 show the concept using a continuous belt passing through pulleys located at each end of a work bench. The belt system allows free lateral movement with tension adjustment on the right.

Figure J1 illustrates the use of a two-point attachment concept with a connecting band holding the straps in a convenient position for reattachment. Figure J2 restrains the crew from one point, a clip in the center belt area. Figures J3 - J4 are photographs of the demonstration model using these systems.

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best available copy.



J1 - Continuous Revolving Belt with Tension Adjustment and Two "D" Ring Fastening Points



J2 - Continuous Revolving Belt with Single Center of Belt Fastener

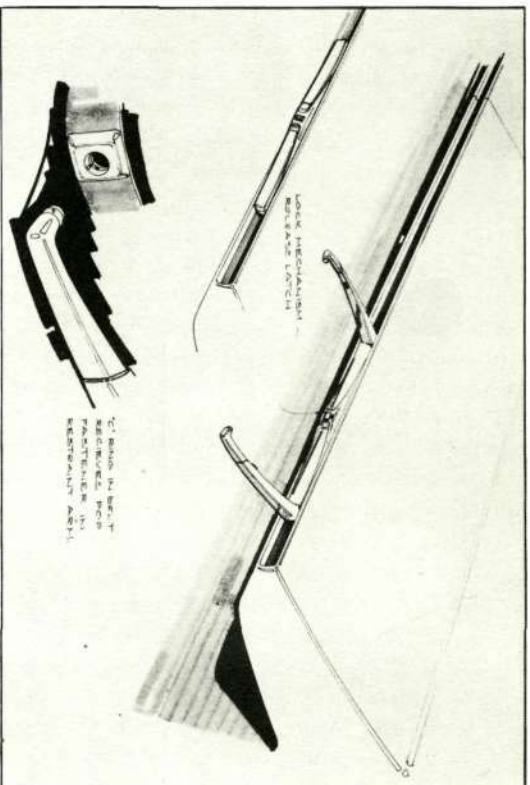


J3 - Demonstration Model of Center of Belt Fastener

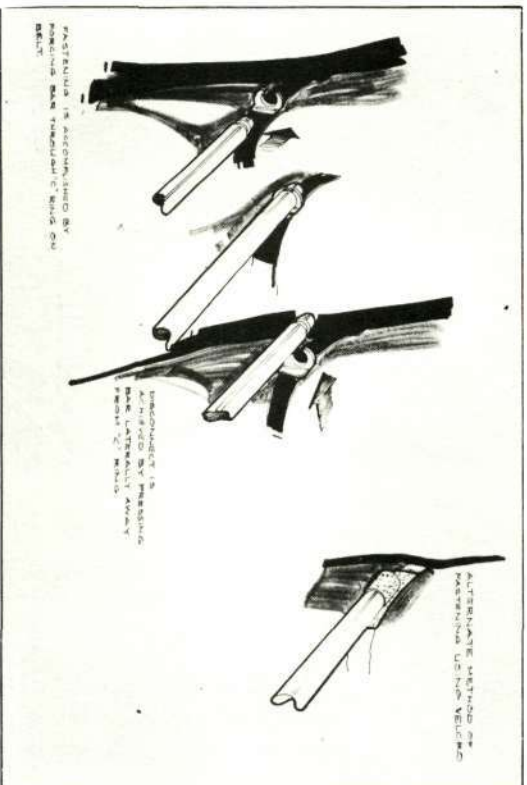


J4 - Demonstration Model of "D" Ring Fastening Techniques





J5 - Adjustable Arms on Guide Rail with Bullet Fasteners



J6 - Variations of Alternate Fasteners



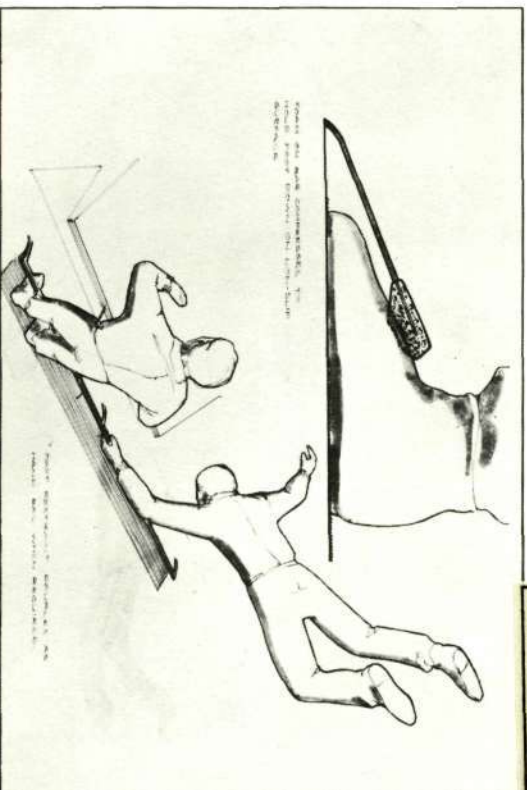
J7 - Demonstration Model of Adjustable Arm



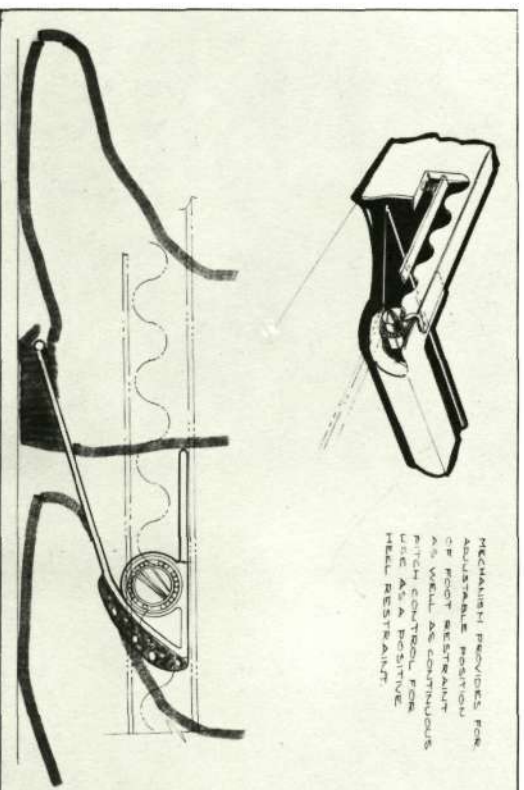
J8 - Detail of Fastener



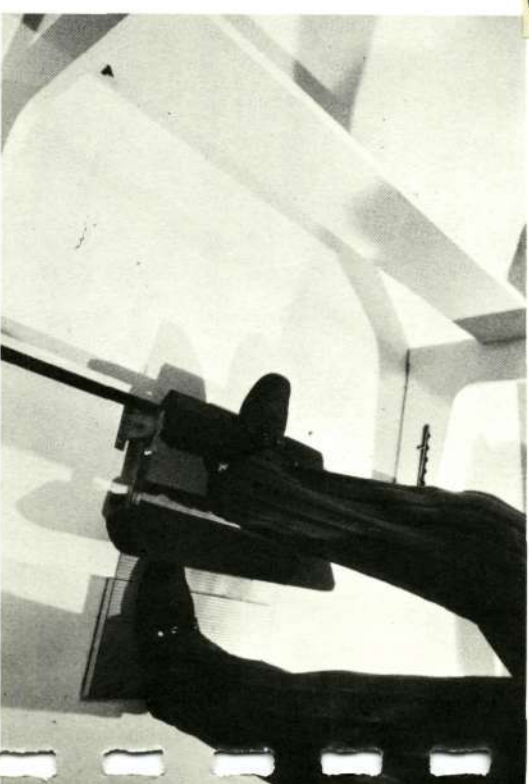
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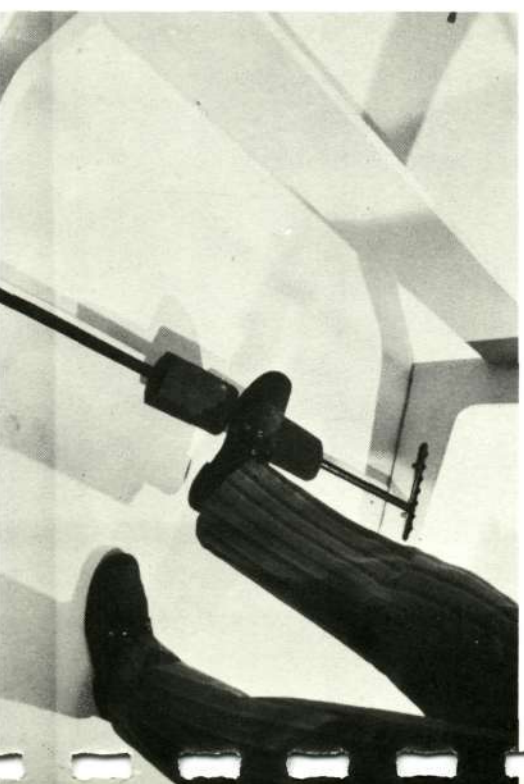
J9 - Tension Bar with Padded Bar



J10 - Adjustable Toe Bar Mechanism



J11 - Demonstration Model Using Toe Bar Adjustment with Spring Tension



J12 - Demonstration Model of Toe Bar Adjustment

## APPROACH B

The concept shown in Figures J5 through J8 permits lateral movement by use of a sliding restraint device held in a track attached to the front edge of the work surface. The slide adjustment has a tightening device to stop side movement when not desired. Adjustable length arms contain male couplers on the ends which connect to female couplers attached to the side of the crewman's belt. When not in use, the arms fold away into a recess under the benches front edge.

## APPROACH C

Figures J9-J12 illustrate toe bar concepts conceived to increase the comfort and effectiveness of the toe bar and allow for an increase in flexibility.

All concepts shown utilize a high friction elastomeric material on the underside of the 'toe bar' to distribute pressure over a larger area of the boot to increase comfort. As illustrated in Figures J10-J12, the flexibility of the toe bar has been increased. Conventional fixed toe bars allow lateral flexibility by enabling the crewman to select the location of the toe bar relative to the work station for maximum effectiveness. J10 illustrates the mechanism which provides for adjustable positioning of a bar foot restraint.

SECTION  
K

## TASK

Shuttle Orbiter Passenger Couch - Full Scale Mock-Up

## CENTER

MSC - Al Louviere

## DATE ASSIGNED

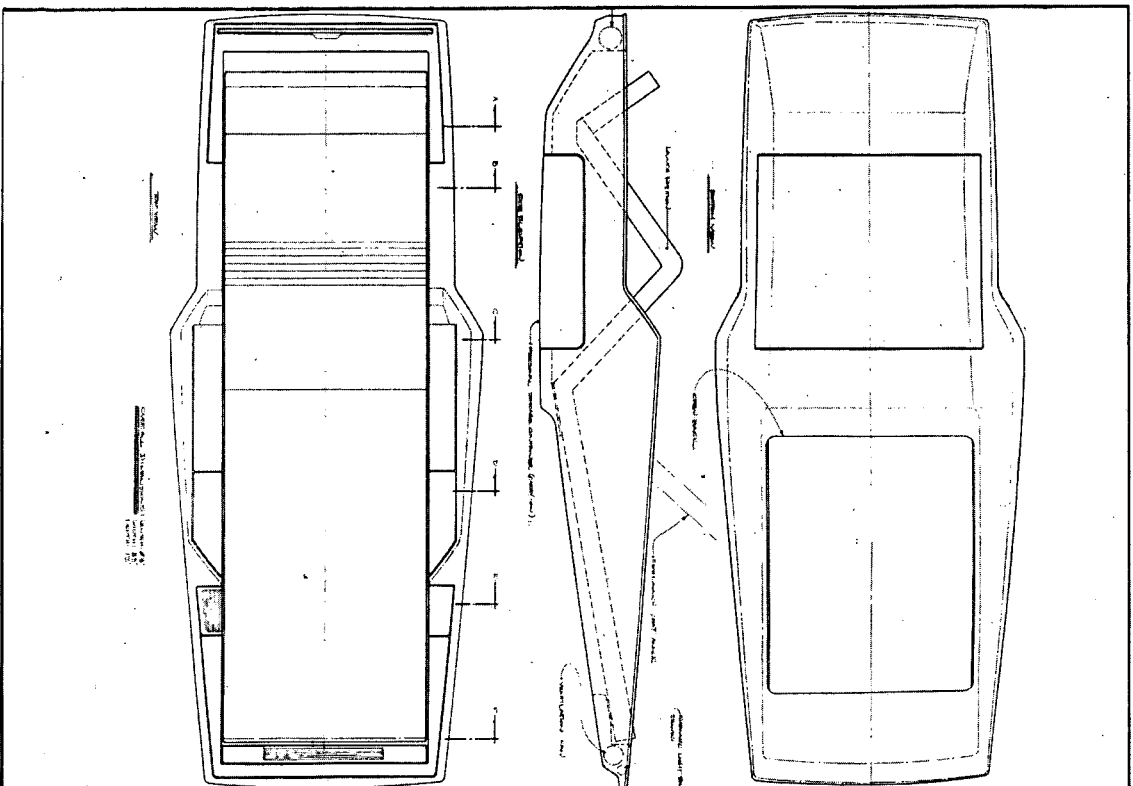
January, 1972

## TASK OBJECTIVES

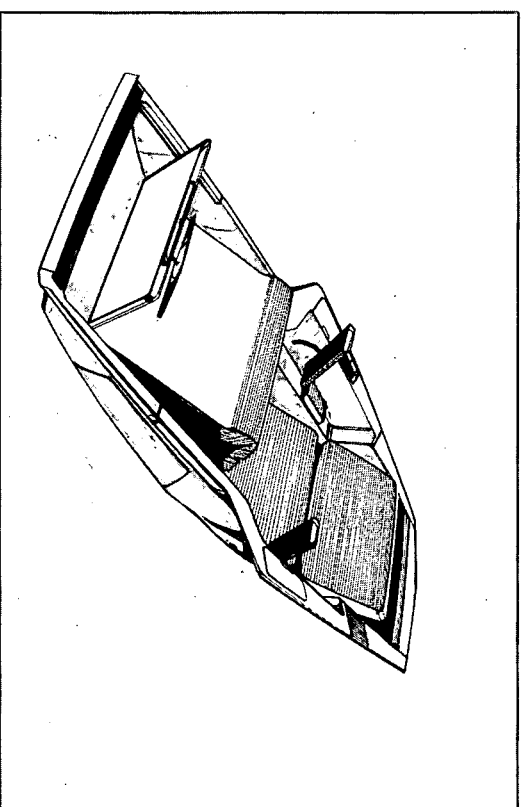
Due to limited volume within the spacecraft, consideration must be given to concentrating several habitability needs into one piece of equipment per crew member. The multi-functional couch is to provide all the crewman's needs for rest and relaxation, eating, sleeping and clerical work. Storage provisions are to be included for the crewman's garments and personal effects and must be accessible from the couch. Privacy is to be provided for sleeping.

## PARAMETERS

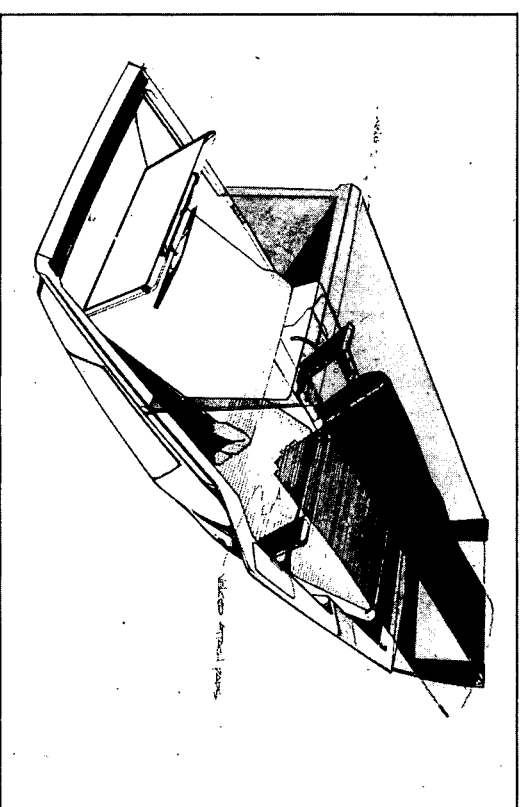
Loewy/Snaith was directed to fabricate a mock-up to demonstrate the features incorporated into the Loewy/Snaith concept and to evaluate them to see whether further effort was warranted. The mock-up was to be constructed to withstand routine ingress and egress in 1-G and neutral buoyancy testing. The couch was to be capable of accommodating various sized personnel and maneuver into several orientations: launch, re-entry, landing, and general 0-G habitability. The mock-up was to include a movable clothing container and one for small personal items as per the earlier Loewy/Snaith concept. Wash containers, emergency oxygen, seat controls and intercom were to be indicated, but not functional.



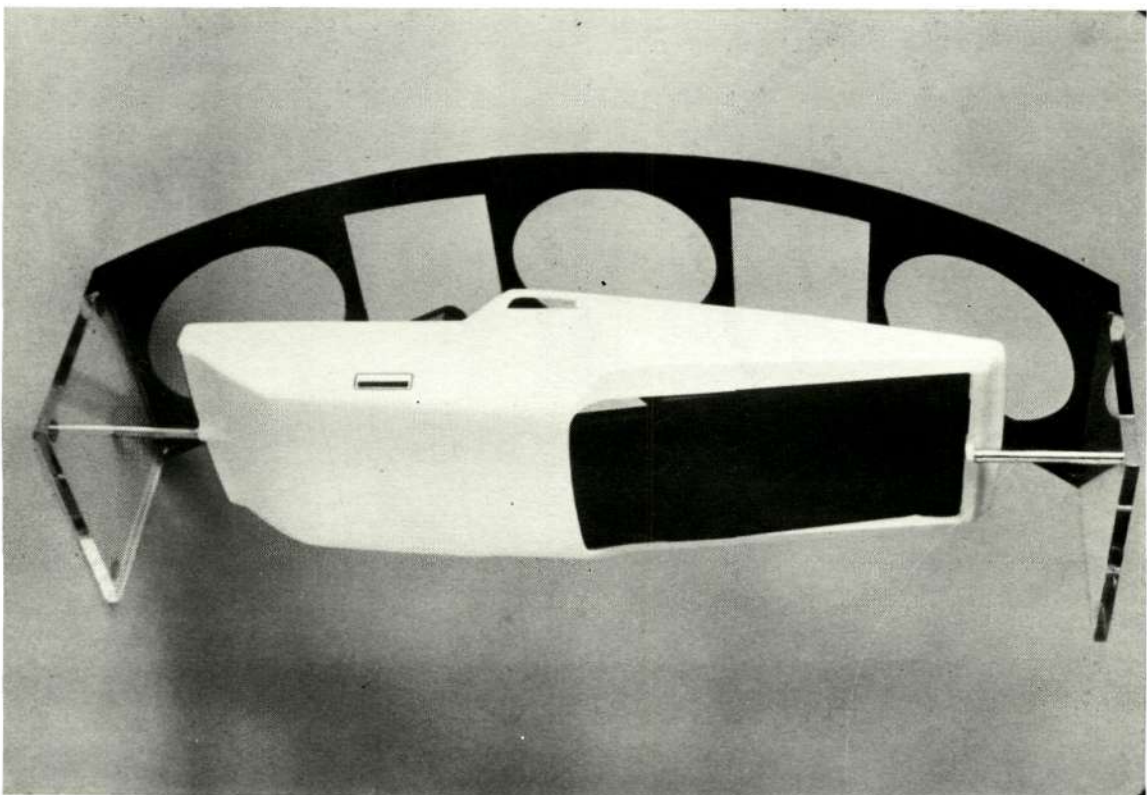
K1 - Mechanical of Full Scale Visual Preliminary Mock-Up



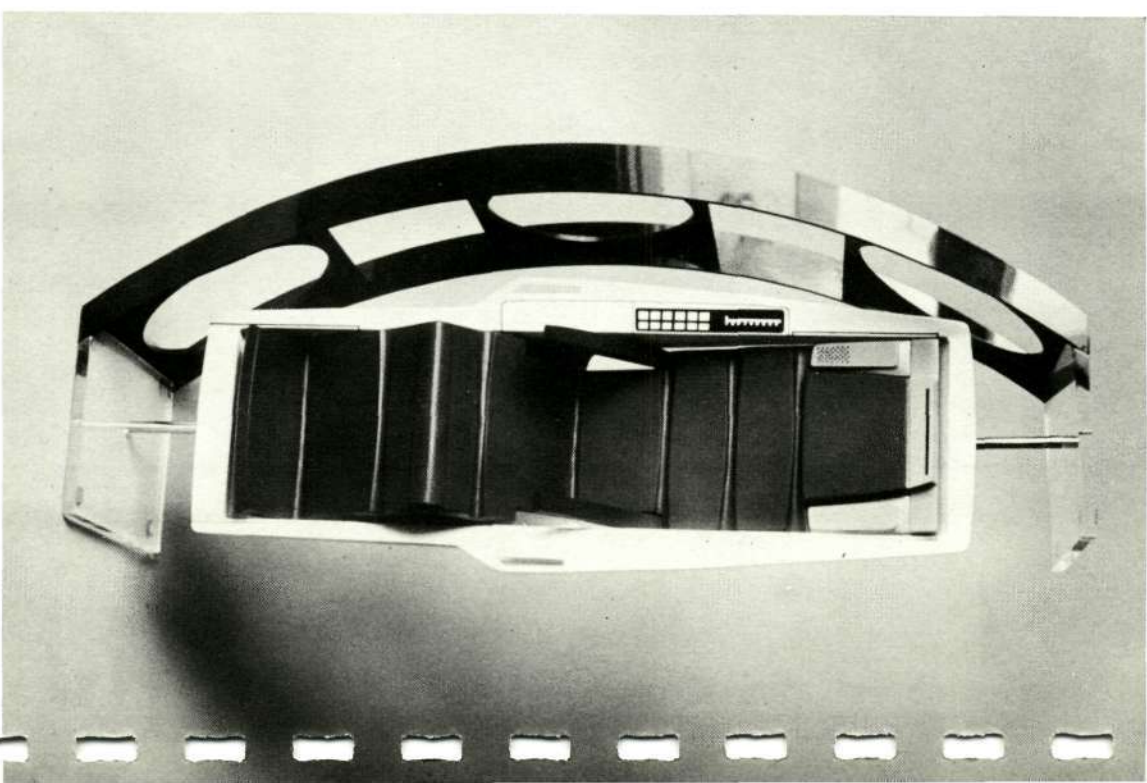
K2 - Preliminary Sketch of Couch Concept on Leisure Mode



K3 - Preliminary Sketch of Couch with Privacy Screen



K4 - Front View of Couch Scale Model



K5 - Rear View of Couch Scale Model

## EXISTING CONCEPT FIGURES K1-K3

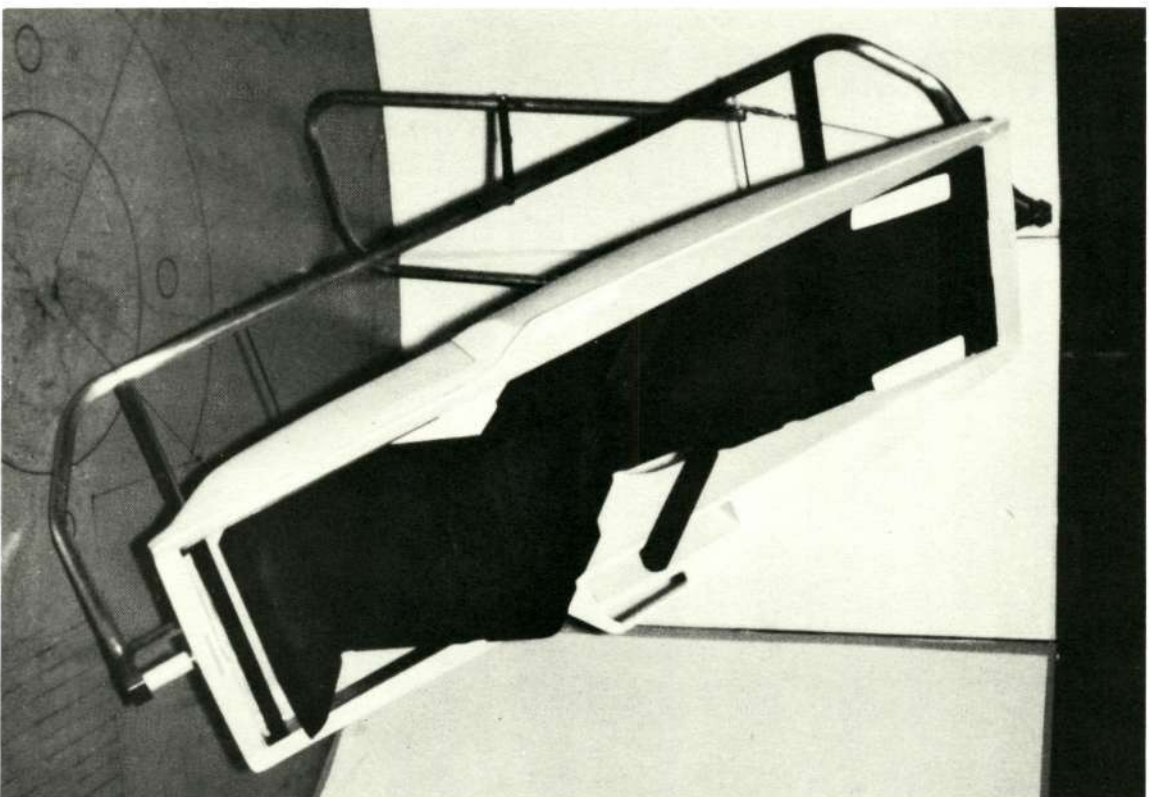
Figures K1-K3 illustrates a mechanical drawing and sketches of the selected version of the couch which was used to construct a preliminary soft mock-up of urethane foam and masonite. Enthusiastic about the results, MSC asked Loewy/Snaith to develop the couch concept in more detail as per the requirements stated in TASK OBJECTIVES.

## OUR APPROACH FIGURES K4-K8

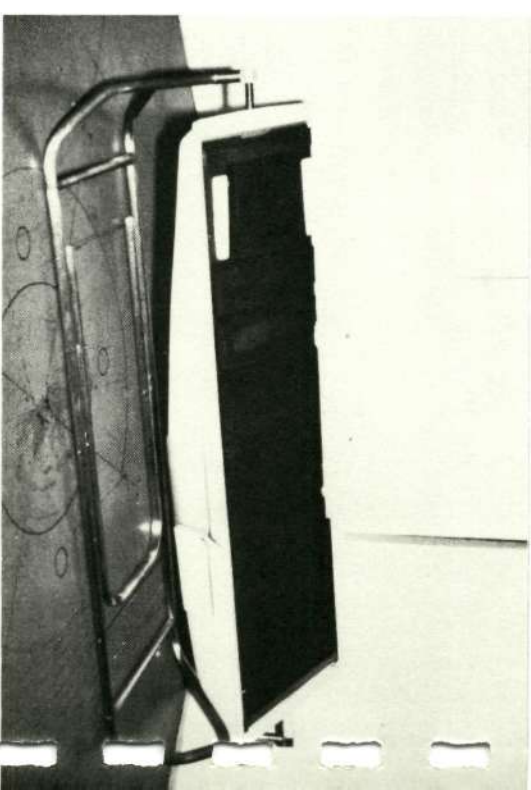
To meet test usage requirements, we fabricated a 2" X 1/4" steel bar frame which was bonded to the interior of the fiberglass shell for maximum stability. Two couch platform inserts, one fixed in the sleep position (Figure K7) and one fixed in the launch/re-entry/social position (Figure K6), were fabricated to allow for full range testing.

A stowable privacy screen system was built into the mock-up based on the preliminary concept illustrated in Figure K3. The system, shown in Figure K8, consisted of fixed roller shade in the top of the couch for over-the-head privacy and a flip-up roller shade device located at the base of the couch which contained a folder three part shade for side and front privacy. The system was designed so that an individual could deploy both shade systems from a restrained position in the couch. The system does not afford the couch occupant complete privacy, but rather light shading for sleep.





K6 - Full Size Demonstration Model in Liesure Mode



K7 - Full Size Demonstration Model in Sleep Mode



K8 - Full Size Demonstration Model in Sleep Mode  
with Privacy Screen

SECTION  
L

## TASK

Data Format Card

## CENTER

MSC - Gordon Rysavy

## DATE ASSIGNED

September, 1972

## PARAMETERS

The Data Format Card, limited to two sides and 5 X 8 inches in size, is to be carried in pockets of the Skylab crewman's garments and it is to be used several times during the mission for a guide for equipment and task evaluation. All evaluations will be voice recorded and transferred to ground control to be considered as input for future mission design and task development.

## TASK OBJECTIVES

During periods of task and compartment evaluations, it is Loewy/Snaith's feeling that all comments should be brief, but allow for personalized responses. To prevent crew impatience with the card, it should clearly outline the proper procedure for use and present a legible sequence.

ANALYSIS OF  
EXISTING CONCEPT

Developed by MSC, Figure L1 illustrates an example of a Data Format Card received for reference. In our opinion, it presents the crewman with a confusing displaying information forcing the individual to search the entire sheet for appropriate items.

PRELIMINARY  
APPROACH

Figures L2-L4 show examples of preliminary concepts developed by Raymond Loewy/William Snaith, Inc. They isolate information pertinent at any one response, avoiding unnecessary search for data. L2 is a circular format with compartment data on the revolving wheel. L3-L4 reorganizes the card into a sleeve carrying constant rating instructions and sliding center with items to be evaluated.



STATE NAME AND DATE (VOICE RECORD ALL REMARKS)		M487 SRF-A		6/4/72																															
<p><b>PARTS 1 &amp; 2.</b> IDENTIFY COMPARTMENT TO BE RATED, THEN STATE LETTER CODE &amp; NUMERICAL RATING FOR EA PARAMETER (COMMENTS ENCOURAGED)</p> <p>EXAMPLE: MD/RH: A,2; B,3; ...</p> <p><b>COMPARTMENTS</b></p> <p>MD/RH: HEAD, SLEEP, EXPT, FWD/DONE, AIRLOCK, MDA/STS</p>																																			
<p><b>PART 1.</b> *Refer to other side of card for definition of ratings</p> <table border="1"> <thead> <tr> <th>RATING/DEFN*</th> </tr> </thead> <tbody> <tr> <td>1 EXCELLENT</td> </tr> <tr> <td>2 VERY GOOD</td> </tr> <tr> <td>3 ADEQUATE</td> </tr> <tr> <td>4 POOR</td> </tr> <tr> <td>5 UNACCEPTABLE</td> </tr> </tbody> </table>						RATING/DEFN*	1 EXCELLENT	2 VERY GOOD	3 ADEQUATE	4 POOR	5 UNACCEPTABLE																								
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L1 - Existing MSC Data Format Card

**INSTRUCTIONS:**  
State name & date (voice record all remarks). For each item to be rated, identify item number, then for each letter code and corresponding numerical rating (comments are encouraged).

EXAMPLE:  
Item 1: A,3; B,2; C,3

STS handtable

RATING	DEFINITION
1 EXCELLENT	Improvements matter personal preference
2 VERY GOOD	Minor improvements possible, but not really necessary
3 ADEQUATE	Some shortcomings found and a few improvements are desirable
4 POOR	Shortcomings found and improvements necessary
5 UNACCEPTABLE	Gross shortcomings found and improvements mandatory

**A. FUNCTIONAL PERFORMANCE OF ITEM**

**B. CONVENIENCE OF IN-USE LOCATION AND ORIENTATION**

**C. COMFORT AND EASE OF USE**

L2 - Preliminary Revolving Format Card with Viewing Cut Out

**M487 SRF-B: STATE NAME AND DATE**  
(VOICE RECORD ALL REMARKS)

**IMPORTANT:** Before beginning report read instructions below.

Item

6. WMC hand washer handrail

Letter Code:

**A** Functional Performance of Item      **B** Convenience of In-Use Location and Orientation      **C** Comfort and Ease of Use

Rating Definition:

- 1 EXCELLENT** - Improvements matter personal preference
- 2 VERY GOOD** - Minor improvements possible, but not really necessary
- 3 ADEQUATE** - Some shortcomings found and a few improvements necessary
- 4 POOR** - Shortcomings found and improvements necessary
- 5 UNACCEPTABLE** - Gross shortcomings found and improvements mandatory

**INSTRUCTIONS:**

State name and date (voice record all remarks)  
For each item to be rated, identify item No., then for each letter code (A, B, C), state letter code and corresponding numerical rating (comments are encouraged)  
Example: Item 1: A,3; B,2; C,3

37. Vacuum cleaner

L3 - Preliminary Format Card with Adjustable Sleeve

1. OWS fireman's pole
2. OWS dome and wall handrails
3. STS handrails
4. MDA handholds/handrails
5. Fecal/urine collect handholds
6. WMC hand washer handrail
7. WMC ceiling handrail
8. Portable handholds (specify where & how used)
9. Triangle shoes/grid
10. Water tank platform
11. ATM foot platform
12. Portable MS12/M479/ERP foot platform
13. Portable PCA foot restraints
14. WD/RM II-duty foot restraints
15. WMC II-duty foot restraints
16. WD/RM table thigh restraints
17. Fecal/urine collect lap strap
18. Sleep restraint
19. Drying stations
20. Portable restraints (which ones/where & how used)

**IMPORTANT:** Before beginning report read instructions below.

**A** Functional Performance of Item      **B** Convenience of In-Use Location and Orientation      **C** Comfort and Ease of Use

28. Seasoning dispensers  
29. Ration urns

**1 EXCELLENT**   **2 VERY GOOD**   **3 ADEQUATE**   **4 POOR**   **5 UNACCEPTABLE**  
State name and date (voice record all remarks)  
For each item to be rated, identify item No., then for each letter code (A, B, C), state letter code and corresponding numerical rating (comments are encouraged)  
Example: Item 1: A,3; B,2; C,3

37. Vacuum cleaner

L4 - Preliminary Format Card with Adjustable Insert

## FINAL APPROACH

Figures L5 and L6 show the final results in the development of a refined Data Format Card. Information has been displayed in an orderly sequence using shades of grey to visually relate similar areas. Instructions and ratings have been placed on the stationary sleeve while the tasks and equipment to be rated are on the sliding section. This positions only one item in the cut-out window at a time, concealing other data until required.

## CONCLUSIONS

The Data Format Card concept is currently being re-evaluated due to dissatisfaction with the basic concept. A verbal response with more meaningful evaluating selections and the option to elaborate when desired is being pursued at MSC.

**PULL UP**

M487 SRF-A

IMPORTANT: Before beginning report read instructions below.

B. Volume of compartment  
 1 Excellent 2 Very Good  
 3 Adequate 4 Poor 5 Unaccept  
 C. Ceiling/floor proximity

**Part 1****Instructions:**

Identify compartment to be rated,  
 then state letter code & numerical  
 rating for each parameter  
 (comments encouraged)  
 Example: WD/RM: A, 2; B, 3;...

**Compartments:**

WD/RM  
 HEAD  
 SLEEP  
 EXFMT  
 FWD/DOME  
 AIRLOCK  
 MDA/STS

**C. IV CARGOES****Part 2****Instructions:**

State letter code & numerical  
 rating for each item  
 (comments encouraged)

**Rating/Use Frequency**

- 1** Daily or every opportunity
- 2** Every other day
- 3** Once a week
- 4** Every 2-3 weeks
- 5** Never (Explain) difficult to use? design? not req?

**PULL UP**

M487 SRF-B

IMPORTANT: Before beginning report read instructions below.

Item  3. STS handrails

**Letter Code:**

**A** Convenience of In-Use Location and Orientation  
**B** Functional Performance of Item  
**C** Comfort and Ease of Use

**Rating Definition:**

- 1 EXCELLENT** Improvements matter personal preference
- 2 VERY GOOD** Minor improvements possible, but not really necessary
- 3 ADEQUATE** Some shortcomings found and a few improvements necessary
- 4 POOR** Shortcomings found and improvements necessary
- 5 UNACCEPTABLE** Gross shortcomings found and improvements mandatory

**INSTRUCTIONS:**

State name and date (voice record all remarks)  
 For each item to be rated, identify item No., then for each letter code (A, B, C), state letter code and corresponding numerical rating (comments are encouraged)  
 Example: Item 1: A, 3; B, 2; C, 3

SECTION  
MTASK  
Housekeeping Equipment StowageCENTER  
MSC - Gordon RysavyDATE ASSIGNED  
September, 1972PARAMETERS  
The requirements of the housekeeping caddy and master stowage unit are as follows:

- 1 The caddy must be capable of being loaded and used while stowed in the master stowage unit.
  - 2 The caddy and the vacuum must be usable as one unit or individually.
  - 3 Placement of the caddy on the body must allow close movement at work station area and easy passage through hatches.
  - 4 Contain storage provisions for waste generated during housekeeping chore and filled general (G. P.) bags.
  - 5 The vacuum requires three feet of hose on the caddy and a detachable five feet of length for galley area - total length, eight feet.
- TASK OBJECTIVES  
The portable unit, resupplied at the master stowage unit would contain limited supplies needed to clean these areas.

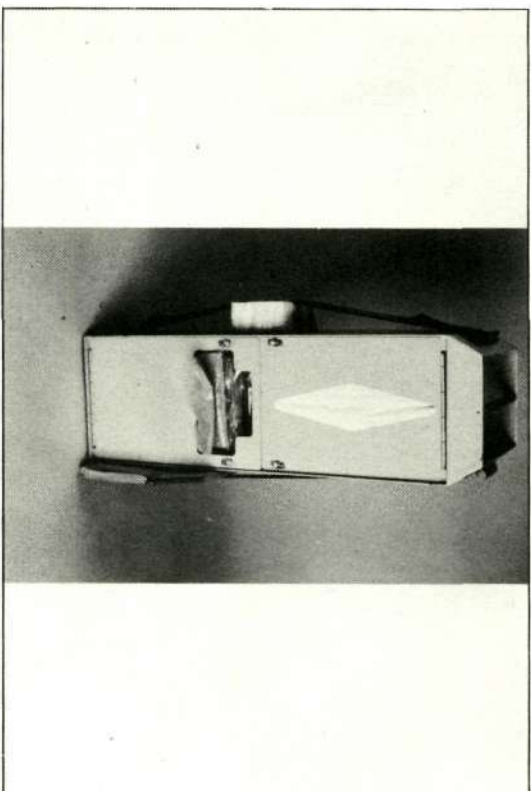
Develop a clean form to prevent soil build up. Contain carrying cleaning agents and devices so as to prevent escape of fluids.

Locate all items within unit for maximum ease of accessibility and in order of frequency of use. Develop a unit form and restraint system empathetic to access requirement and zero-G movement.

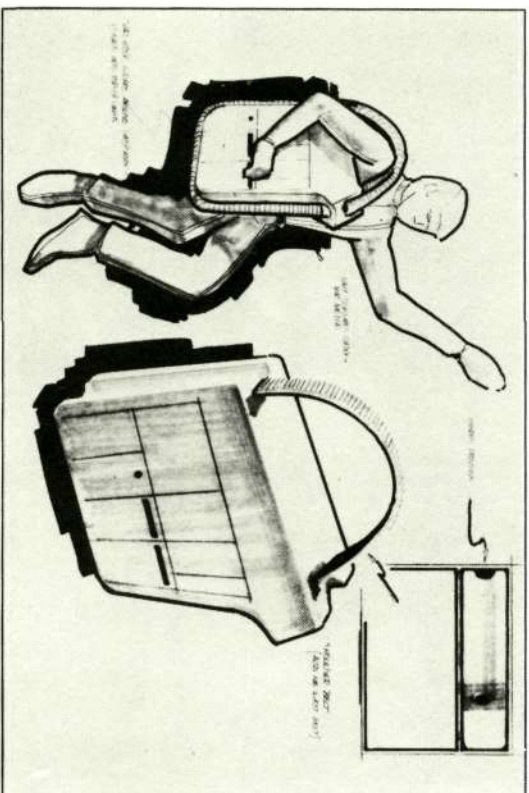
# ANALYSIS OF EXISTING CONCEPT FIGURE M1

The present master stowage unit exposes all cavities to the housekeeping attendant. This gives him a full view of needed items to refill the caddy. The following problems do exist, however:

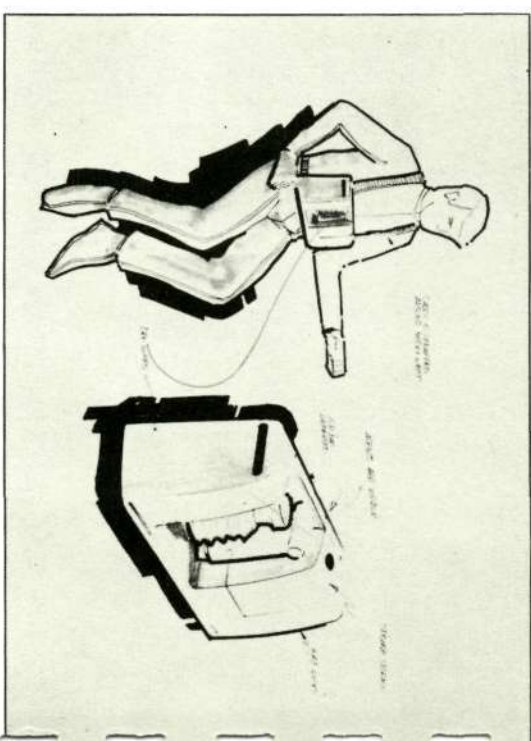
- 1 The caddy must be removed to reload.
- 2 No logical organization of component placement is apparent.
- 3 No restraint device has been provided for use away from the master unit.
- 4 Use of the vacuum while in the galley area requires its removal of the entire unit for attachment of the hose.
- 5 Assembling the unit for use away from the master unit requires an excessive amount of time.
- 6 The open configuration of the caddy does not provide spillage protection.
- 7 No provision has been made for containing the vacuum hose while maneuvering throughout the spacecraft.



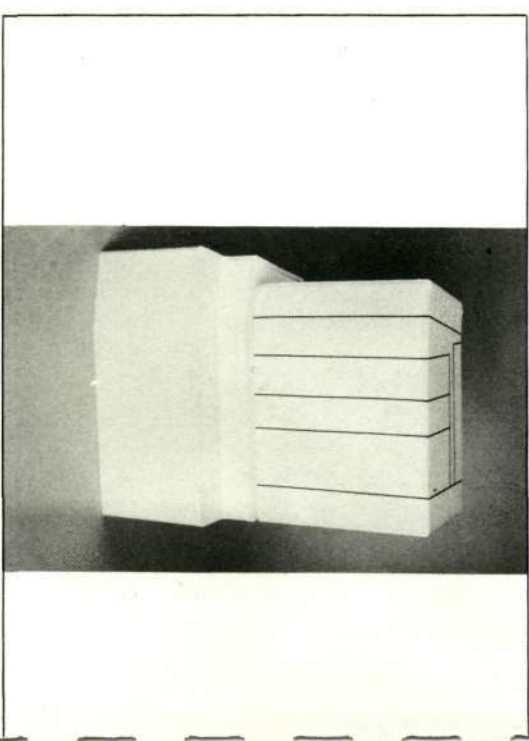
M1 - Existing MSC Housekeeping Caddy



M2 - Preliminary Vac-Caddy Concept



M3 - Preliminary Front Mounted Caddy Concept



M4 - Preliminary Mock-Up of Vac-Caddy

Using the work sequence described in paragraph 1.4 of the "Preliminary Design and Development of Housekeeping Systems for Manned Spacecraft", the following use description was established:

Vacuum Cleaning (Either in storage unit or remote location.)

- 1    Attach hose.
- 2    Attach vacuum accessory to hose nozzle.
- 3    Clean area.
- 4    Switch accessory (repeat 3).

Emergency Clean

- 1    Use expanded sponge and/or wet wipe.

Wipe Cleaning

- 1    Sanitation and/or disinfection agent.
- 2    Wet wipe.
- 3    Dry wipe.
- 4    Deposit used dry wipe in G. P. bag.
- 5    Pick up full G. P. bags, if necessary.



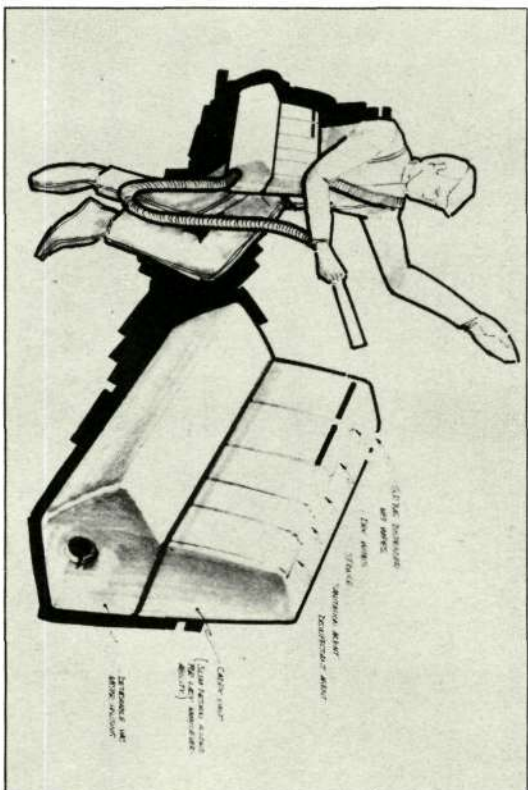
We have arranged the storage units based on the frequency and order of use as follows:

- 1    Sponge/wet wipe dispensers.
- 2    Sanitation and disinfectant agents.
- 3    Dry wipe towel dispenser.
- 4    G. P. bag dispenser.
- 5    Full G. P. bag storage.

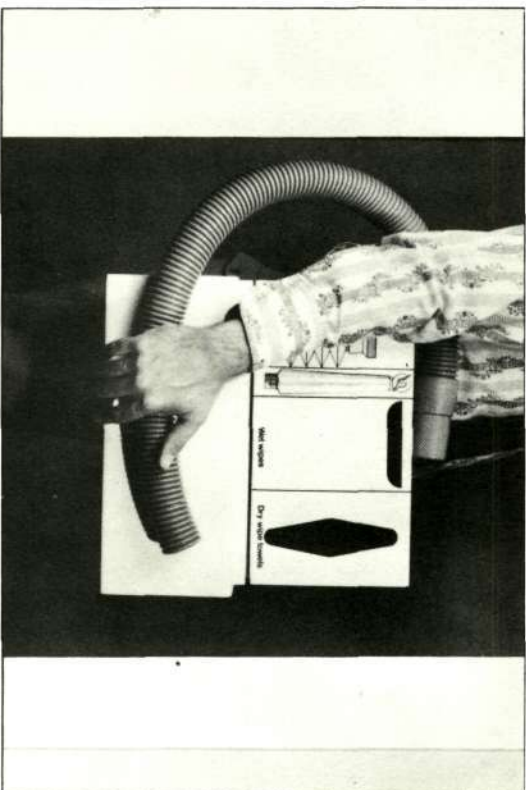
PRELIMINARY  
ARRANGEMENT  
STUDIES  
FIGURES M2-M6

Following the task sequence evaluation, preliminary three dimensional studies were conducted to define the approximate volume necessary to contain the housekeeping equipment. The required volumes were configured to obtain minimum overall area to enclose the necessary items and to evaluate the effectiveness of the proposed component layout relationships.

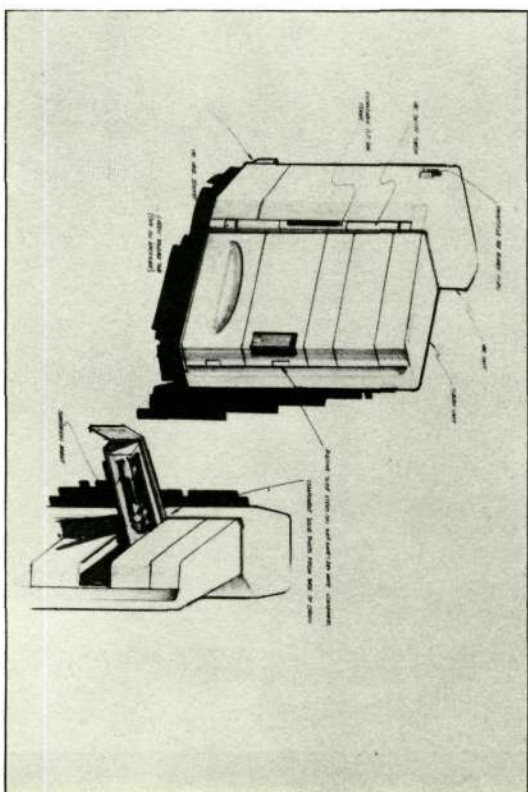
Body placement and task operations of the caddy were studied and a position under the arm wrapping to the rear was considered the most desirable. The individual has access to all stored components and the wrap around hose and it did not appear that the unit would inhibit movement.



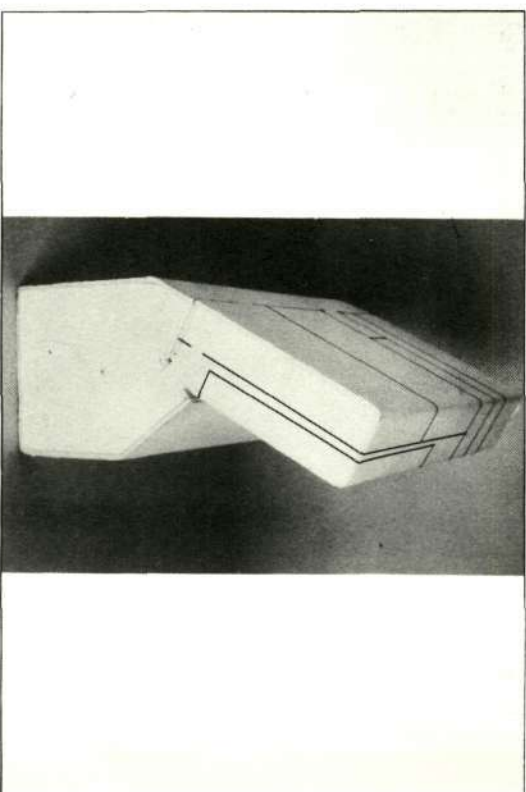
M5 - Preliminary Vac-Caddy Concept Mounted Underarm



M6 - Preliminary Mock-Up of Side Mounted Vac-Caddy Concept



M7 - Final Vac-Caddy Concept



M8 - Mock-Up of Final Concept

Figure M2 is a side mounted vac/caddy. The vac hose is stored in a peripheral recess. Shoulder and waist straps restrain it to the body. The minimal 3-1/2 inch width allows free arm movement. Overall size (14-1/2" X 18") was considered restricting and the layout was unmanageable by a left hander.

Figures M3 and M4 represent a convenient location of stored components. It does not obstruct the users passage through hatches, however, if the vacuum unit were to be used, it would have to be mounted in an area other than the chest to avoid inhibiting leg movement, as illustrated in Figure M3.

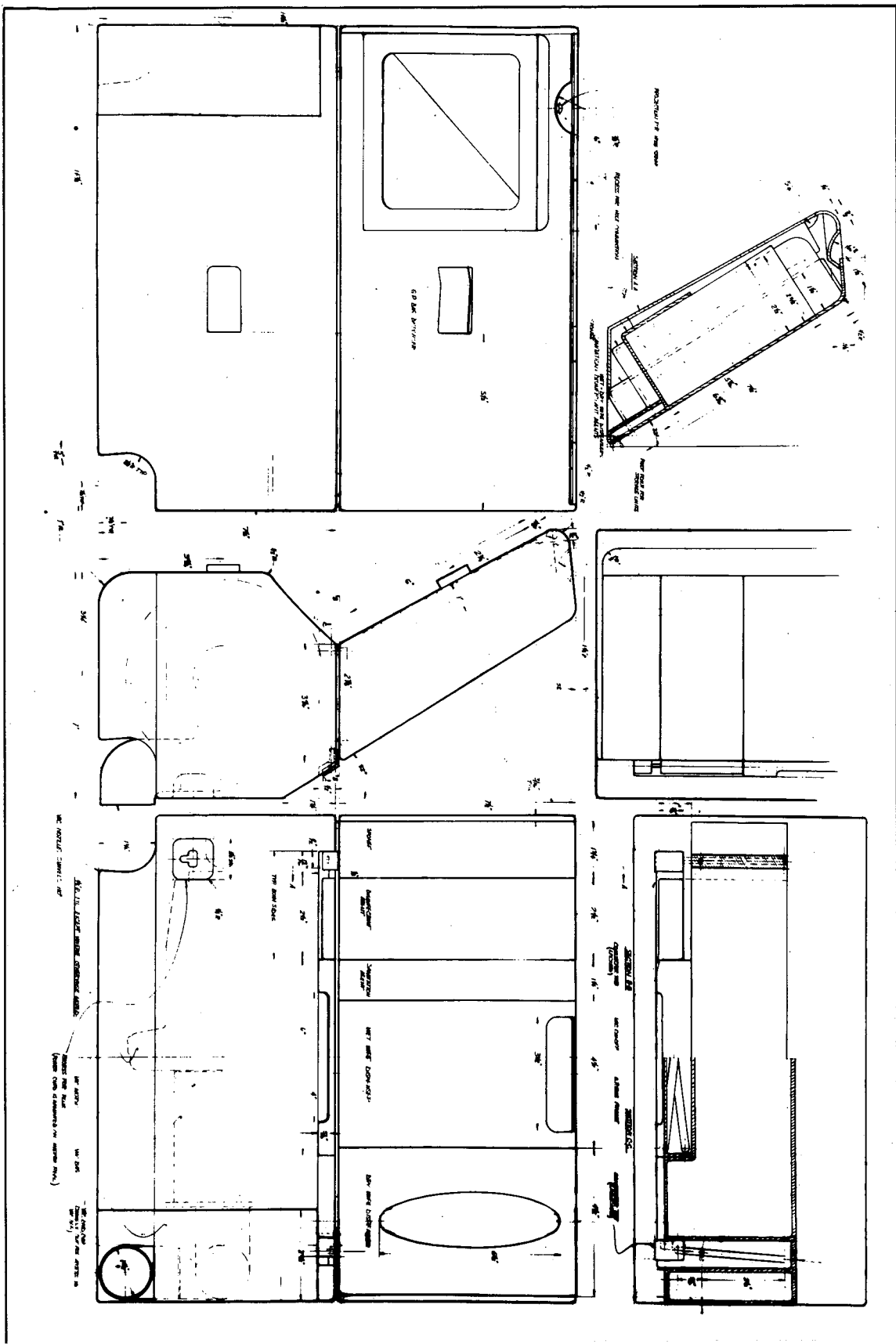
A slim side mounted caddy is illustrated in Figures M5 and M6 with a detachable vacuum unit. The user's arm is free to move uninhibited, however, access to the rearmost storage unit is difficult.

The selected concept is configured as a wrap around unit, positioning all storage units vertically down the crewman's side for equal ease of access to all units.

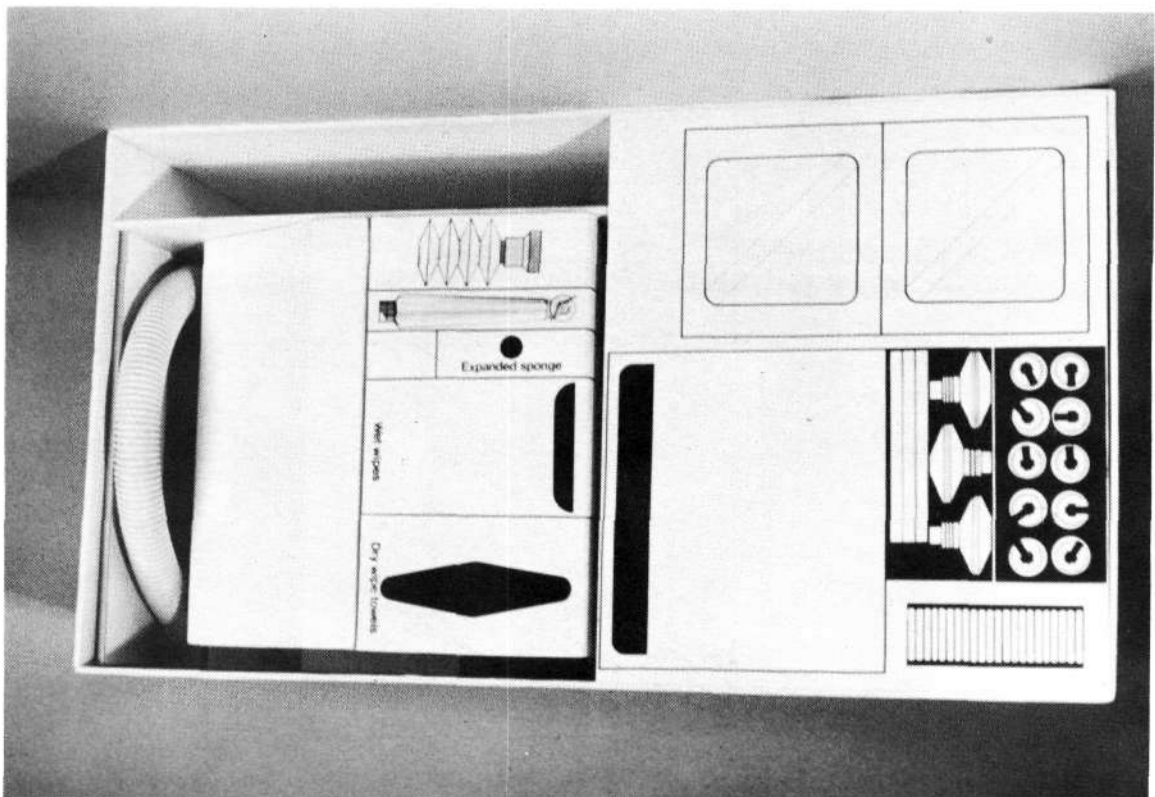
#### OUR APPROACH FIGURES M7-M19

The vacuum hose is stored flush with the back of the unit to prevent snagging during periods of crewman transfer and all controls are placed near the top for easy access.

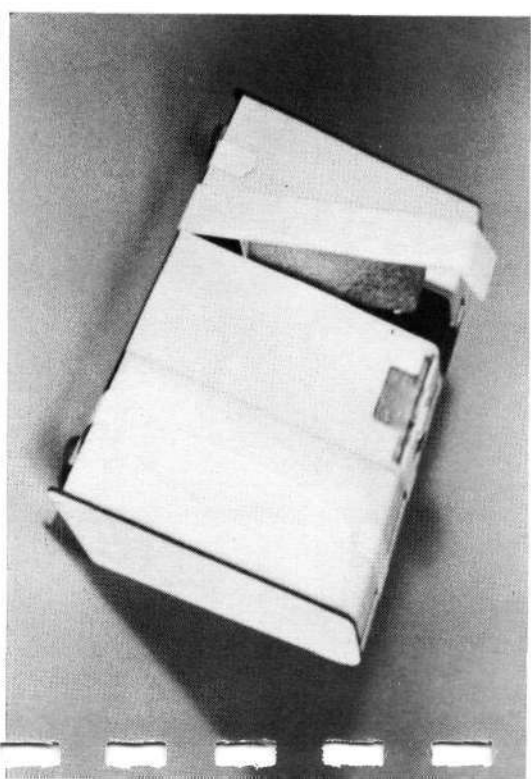
The outlet cord on an inertia reel houses the cord when not in use. When extended the desired length, the cord is snapped into a friction fit groove to prevent an accidental recoil.



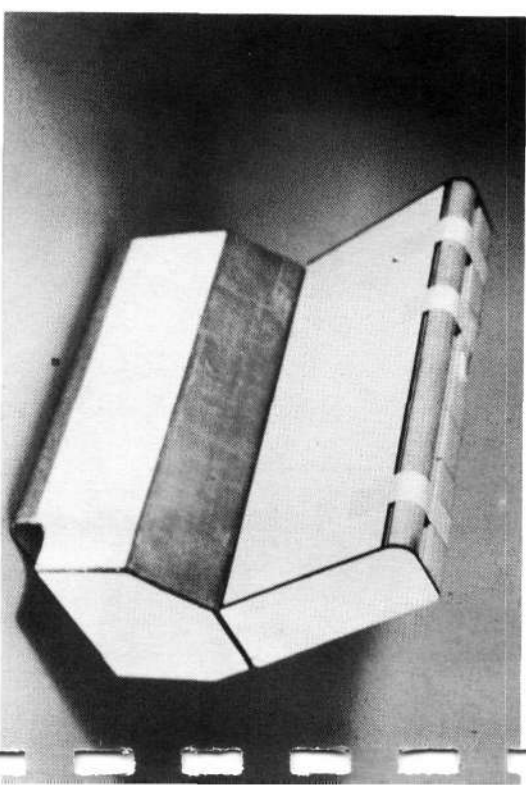
M9 - Mechanical Drawing of Vac-Caddy



M10 - Unfinished Model in Master Stowage Unit



M11 - Unfinished Caddy Component - Sponge  
Compartment Open



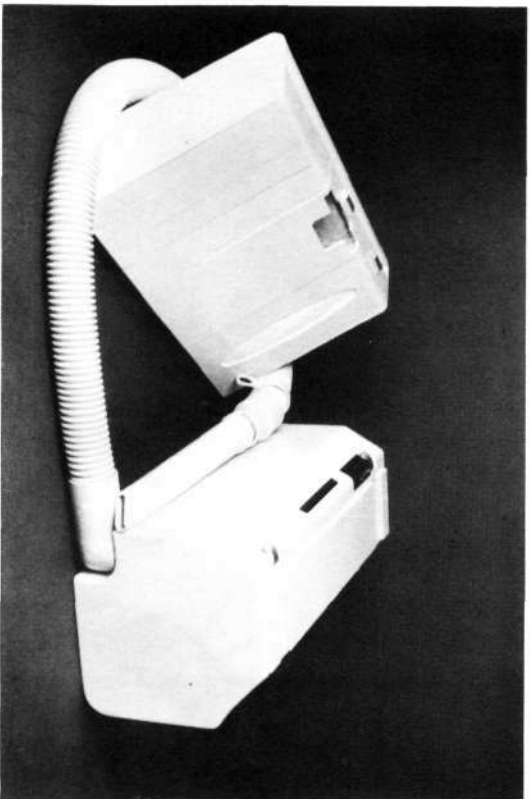
M12 - Unfinished Vac-Caddy Model - Back Side

M16 - Photograph of Final Model

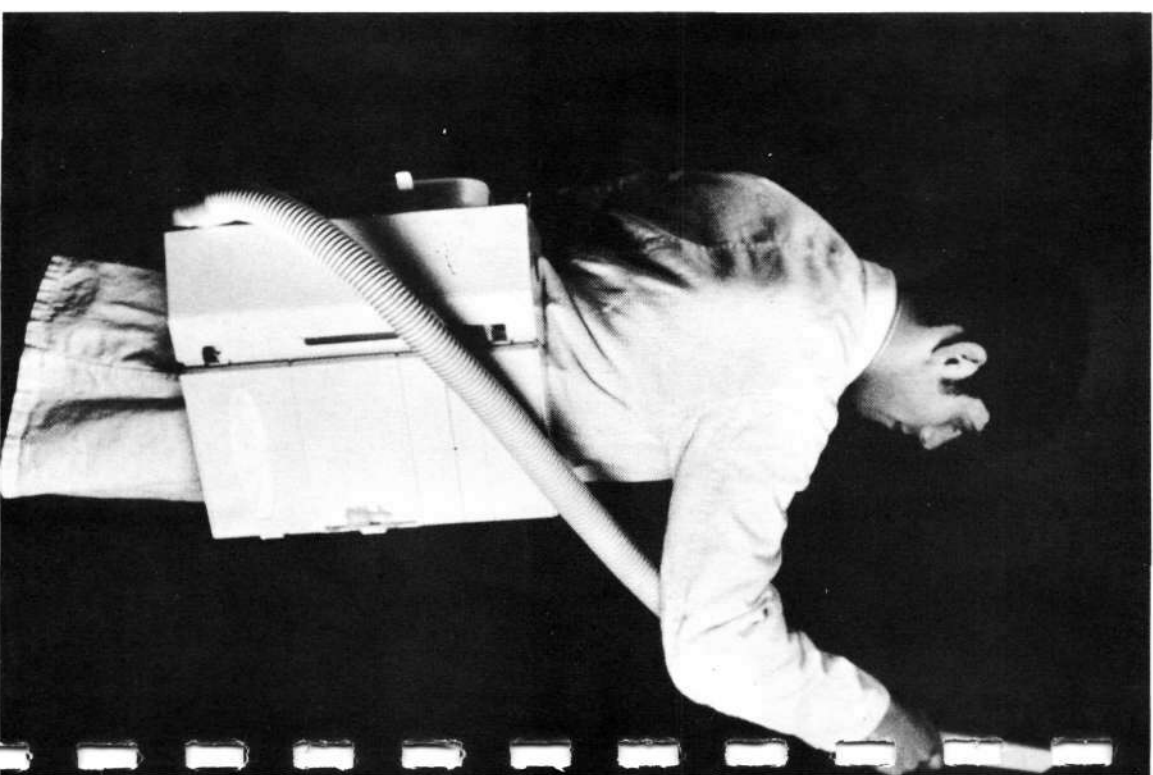




M17 Caddy Unit Mounted on Belt



M18 Vacuum and Caddy Unit in Two Parts



M19 Vacuum and Caddy Unit Mounted on Attendant's Belt

SECTION  
N

TASK Shuttle Orbiter Storage Locker System

CENTER MSC Houston - Gordon Rysavy

DATE ASSIGNED May 1, 1972

## SCHEDULE

The tentative due date for concept development was originally scheduled for June 21, 1972. As interest grew at the Manned Spacecraft Center for several proposed systems for storage lockers, it was decided that further investigation was warranted due to the importance of the storage locker system. A final demonstration model was constructed and presented January 27, 1973.

## PARAMETERS

- 1 System to be loaded in 1-G, utilization of system in 0-G.
- 2 Simplified installation methods to facilitate ground crew re-supply procedures.
- 3 Modular breakdown at locker heights to increments of 6, 12, 18 and 24 inches.
- 4 Depth limited to 18 inches.
- 5 Frontal area size limitation, 24" X 24", to facilitate movement in orbiter and limit weight to manageable limits.



6 Withstand intensive launch vibrations.

7 Ability to remove storage lockers in 0-G and transport to other areas of the craft.

8 Provisions to carry locker, or part of it, to other areas of the craft.

9 Adequate restraints within locker, to secure wide variety of items.

# TASK OBJECTIVES

Because mission requirements may vary from one mission to another, MSC requested that Loewy/Snaith develop concepts for a locker system which provide for the containment of a variety of experiments, equipment, and mission supplies within the orbiter crew compartment. MSC desired a system with enough flexibility to allow for last minute changes in inventory prior to launch.

## ANALYSIS OF EXISTING CONCEPT FIGURE N1

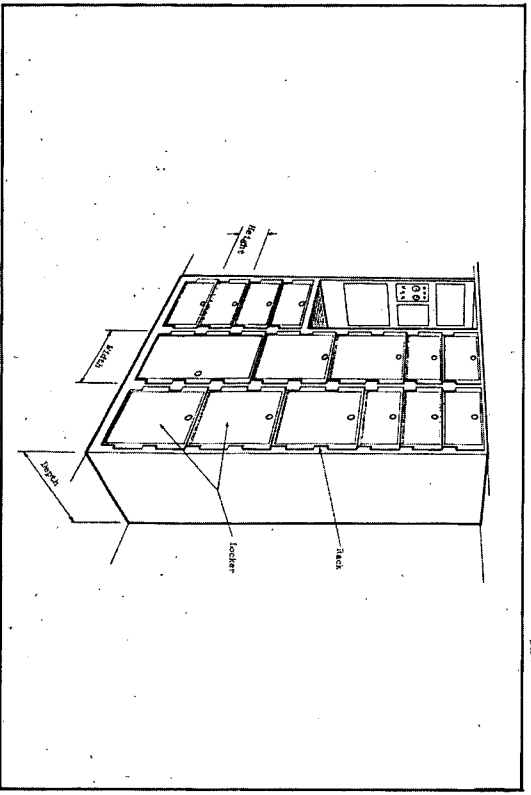
### Pro

- 1 Allows for height adjustments based on 6" modular increments.
- 2 Structured to withstand launch vibrations.
- 3 Storage lockers removable for replacement and access.

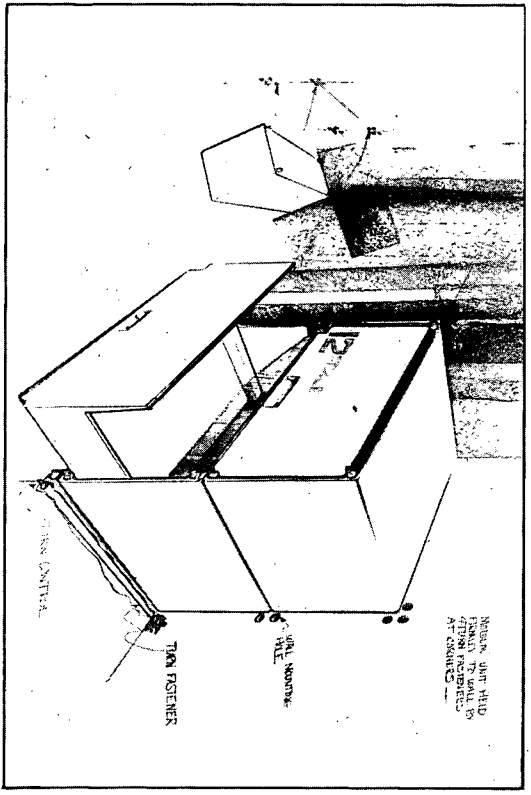
### Con

- 1 Width is restricted to that designed into the system.
- 2 Requirement to completely rebuild if one complete column were to be removed.

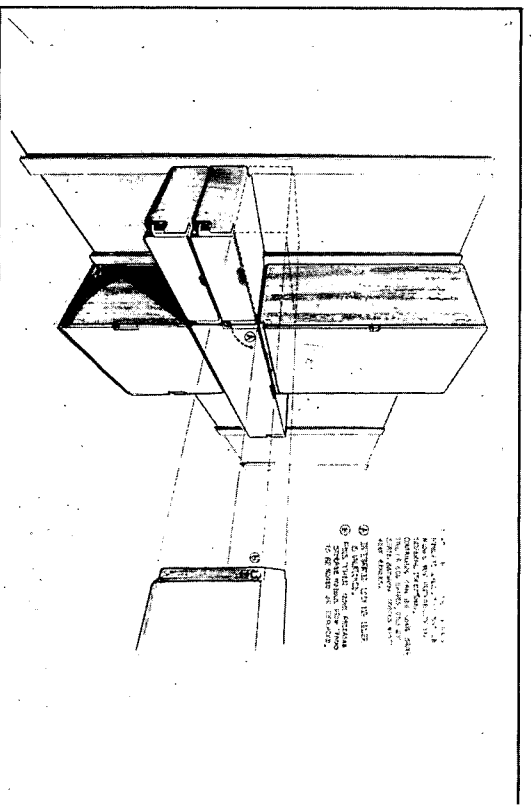
Reproduced from  
best available copy.



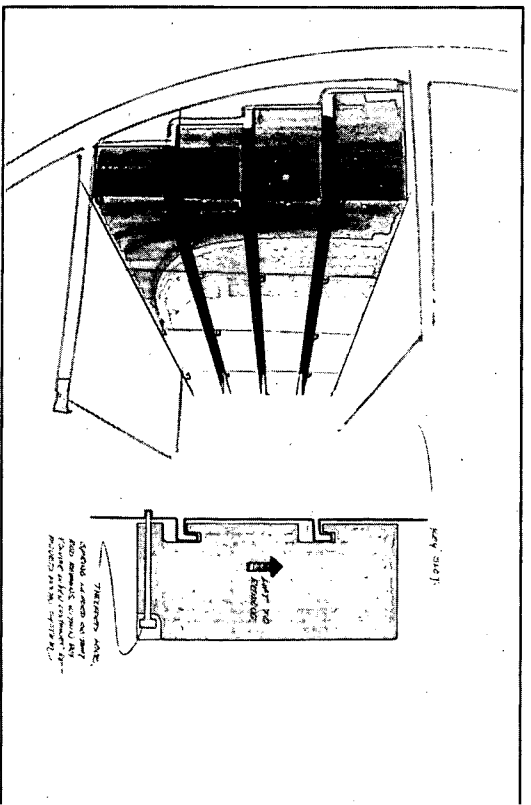
N1 - Existing MSC Storage Locker System



N2 - Preliminary Storage Locker System with  
Drawer Access



N3 - Preliminary Storage Locker with Concealed  
Tracks and Exposed Locking Levers



N4 - Preliminary Storage Locker Concept Wall  
Hung and Restrained

- 3 No visible means of transporting individual lockers.
- 4 Inconvenient method of relocating components of a locker to other areas of the craft.

## LOEWY/SNAITH APPROACH

### I

#### Preliminary Phase

Figure N2 uses a structural wall upon which the storage modules are fastened. The drawer of the locker allows access to the far end. A turn fastener exposed on the front surface extends through the units and ties into the wall via threaded recepticals. It was felt that this fastening technique was not positive enough and required a controlled tolerance.

Figure N3 allows more vertical adjustment. Closely spaced horizontal grooves, located behind the track at intervals compatible with the vertical module, allow for vertical adjustment as required. Over-the-center locking pins on the rear surface of the lockers, interlock with the grooves.

Figure N4 illustrates a system of storage lockers of varying depths designed to make use of the volume created by the spacecraft's curvature. Previous concepts limited lockers to a depth of 18 inches, an acceptable reach distance for an average crewman. The maximum depth is still 18 inches, however, near the base of the curve, depths may be decreased at 6 inch increments. This takes advantage of otherwise unusable space behind the lockers or where available storage depth is less than 18 inches.

N8 - Sample Cross Section of Storage Locker Interior

The "shelf" feature under the lockers add support while loading units in 1-G and act as a bearing surface upon which the key slot brackets may be mounted. Threaded tension bars are utilized to torque the storage unit against the support wall. A disadvantage exists in the requirement for vertical space between each storage unit. The "key" requires sliding the bracket into a slot and lowering the locker into place.

Loewy/Snaith, Inc. also studied a modular technique for assembling various size storage units from a few common units as illustrated in Figure N5. MSC pointed out that a locker which was not made up of one piece, would be destroyed by launch vibrations.

Figure N7 illustrates a problem which we addressed lightly in the preliminary phase; the problem of recording and communicating the organization of the on-board inventory of stored items. The approach shown, utilizes an alpha numeric graphic system keyed to an inventory book supplied each crewman. By color coding or numerically coding the over-all lockers to areas within the crew compartment the system would, through the use of, for instance a color, number and letter, lead the crewman from the general to the specific area of storage.

Assuming that containers size variations are possible based on a 6 inch modular growth, the problem still exists as to how the interior of the containers will accommodate the variety of article sizes and shapes to be stored for each mission. As illustrated in Figure N8, an interlocking system of extruded storage pallets was conceived as an answer to this problem.

The interior of the master storage case may be divided up as required by using these extruded flat pallet inserts which interlock with the extruded inside walls of the master case and interlock with each other in the same manner. Using pallets as wide as the master case interior,

the case can be subdivided vertically on one inch increments into any propositions desired relative to mission storage requirements. Sliding various length pallets into the case vertically between horizontal pallets allows one to subdivide the case horizontally as required. The end result of this system is that a totally flexible storage system from which individual pallets on total groupings of pallets and the items they contain may be removed as desired.

## II

### Detail Development Phase

With the acceptance by MSC of the pallet system detail concepts were developed regarding methods of locking the pallets to the master storage units and each other, and methods of restraining articles of various sizes and shapes to the pallets.

Figure N9 shows a cut-away detail of the locking mechanism selected and Figures N10-N13 show a few of the restraint concepts presented.

#### a) Locker Mounting

Master locker installation is accomplished by inserting positioning cones located at each rear corner of the locker in cone-shaped recesses in the mounting plate. The recesses are arranged in a 2 inch interval in a square matrix to allow for horizontal and vertical positioning flexibility. Astro pin devices were considered for use in securing the lockers to the support panel, however, we understand that problems exist with these devices which obviate their use. The restraint system utilized consists of spring loaded threaded fasteners located in the corners of the rear surface of the storage unit which retract to a flush position when not in use.



Fastening the lockers to the wall is accomplished from the front surface and does not require opening the locker. Located on the front surface in each of the front four corners (Figure NI7 and NI8) are access holes behind which are located "socket heads" rods which are threaded at the rear end for torquing to the mounting surface.

Each locker is supported independently allowing last minute changes in locker mix.

#### b) Locker Sizes

Special cases may exist where unusually large lockers may be required to enclose some experiments. Generally, for continuity, however, the modules have been limited to the following sizes: 6H X 24W X 18D, 12H X 12W X 18D, 12H X 24W X 18D, 18H X 24W X 18D and 24H X 24W X 18D.

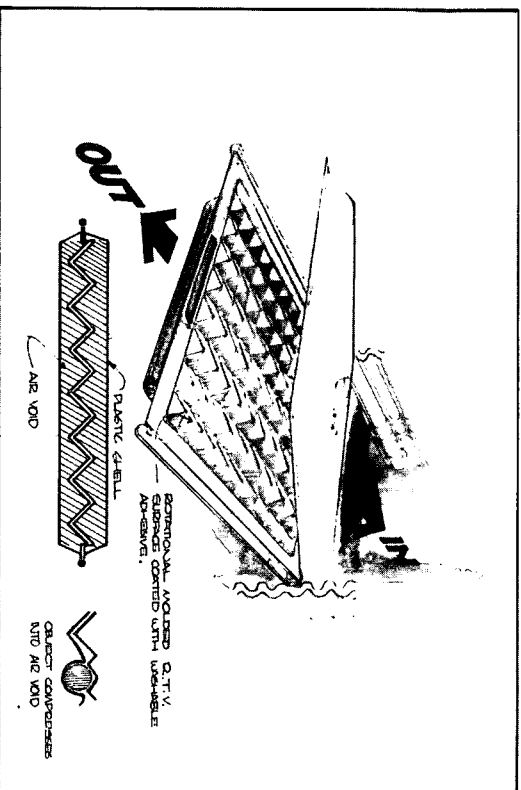
All storage locker combinations are a breakdown of 24"H X 24"W X 18"D "master module" shown in Figure NI5. To illustrate this, Figure NI6 spotlights four 12W X 12H X 18D" storage lockers, which could be replaced by any of the other formats.

NI7 illustrates a close up view of repetitive track extrusion shapes located on all four interior surfaces and the corner mounting socket head and door access hole. As Figure NI9 shows, each door lock on the double door lockers acts independently. The illustration also shows that the handle lever serves to locate any alpha-numeric identification.

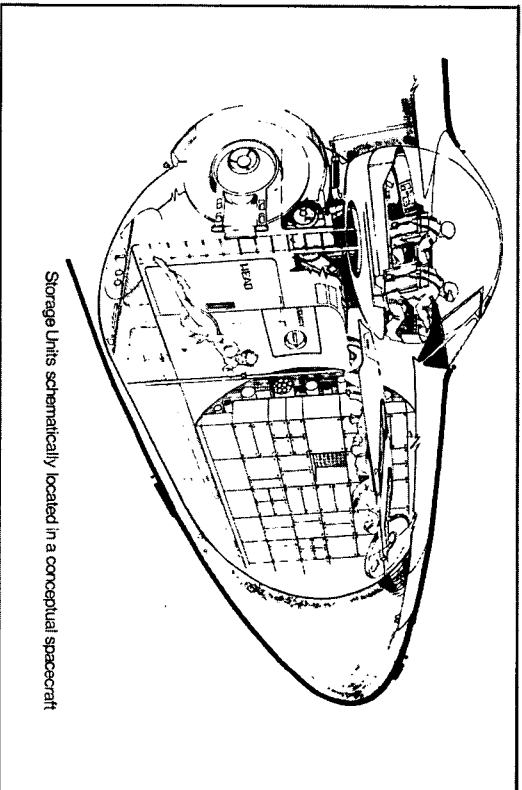
#### c) Locker Interior Flexibility

The flexibility of the storage locker system is dramatized in Figures N20-N22. The "C" shaped extrusions allow one or many component laden trays to be mounted in the same locker horizontally or vertically

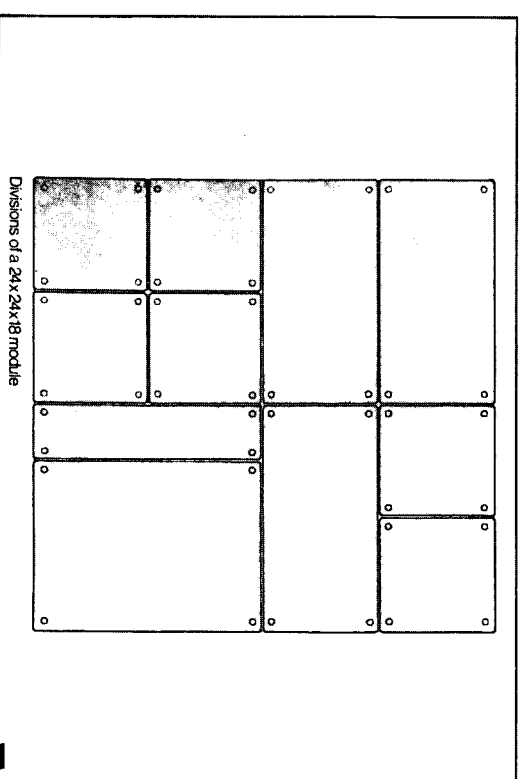




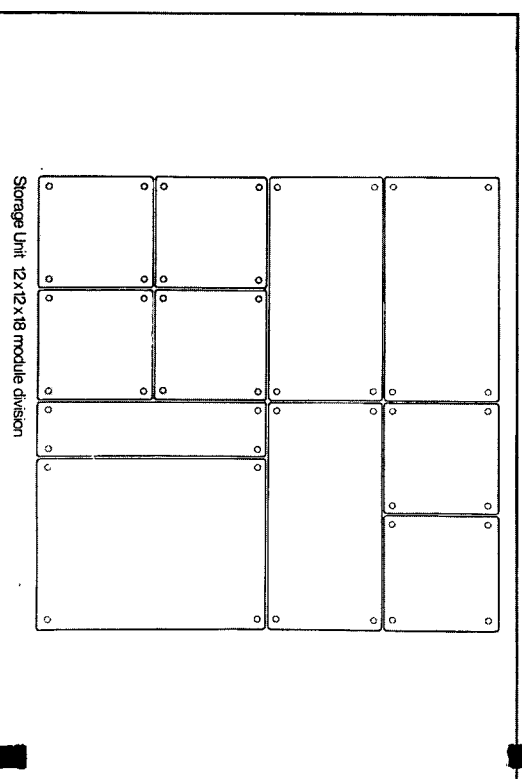
NI3 - Preliminary Storage Locker Tray -  
Small Object from Restraint



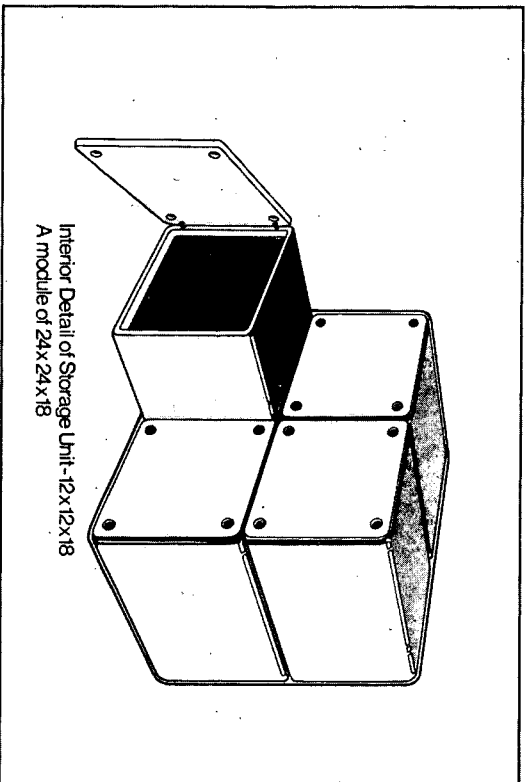
NI4 - Final Storage Locker System Positioned  
on a Mounting Wall



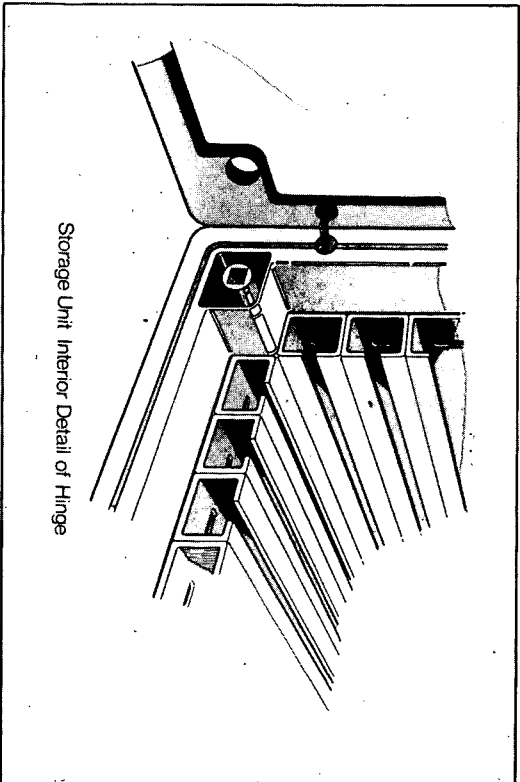
NI5 - Several Locker Groupings Interchangeable  
with a 24H X 24W X 18D Module



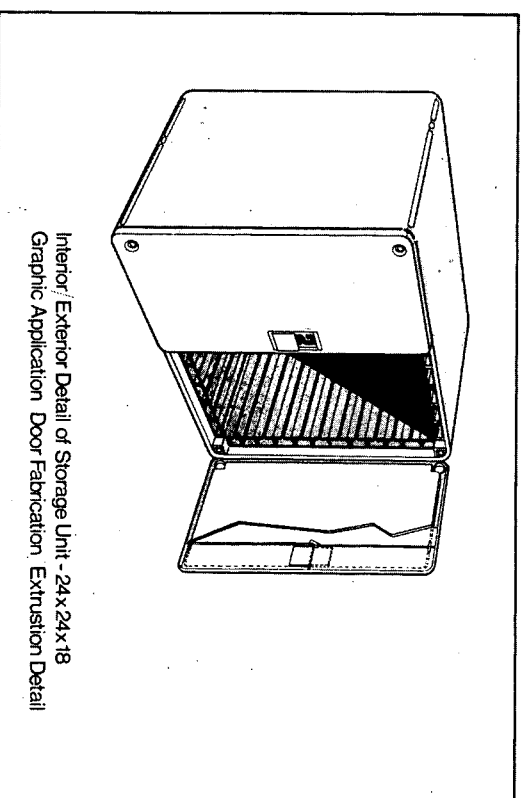
NI6 - Four 12H X 12W X 18 Lockers Replaceable  
with Illustrated Layouts



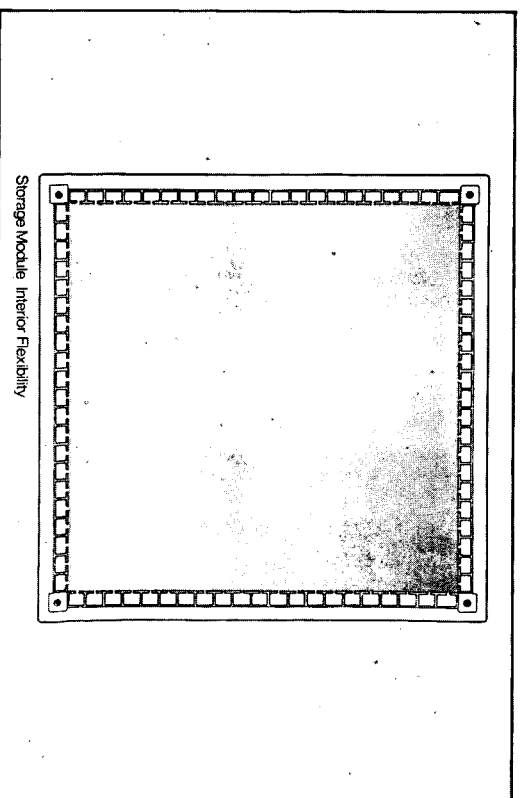
N17 - Locker Interior Without Trays Inserted



N18 - Locker Interior Detail



N19 - Locker Door Mechanism and Graphic Detail



N20 - Extrusion Layout in Storage Locker

depending on orientation requirements relative to G-loads and space available.

The drawer type character of the trays allow access to the deep end of the storage locker by sliding trays out.

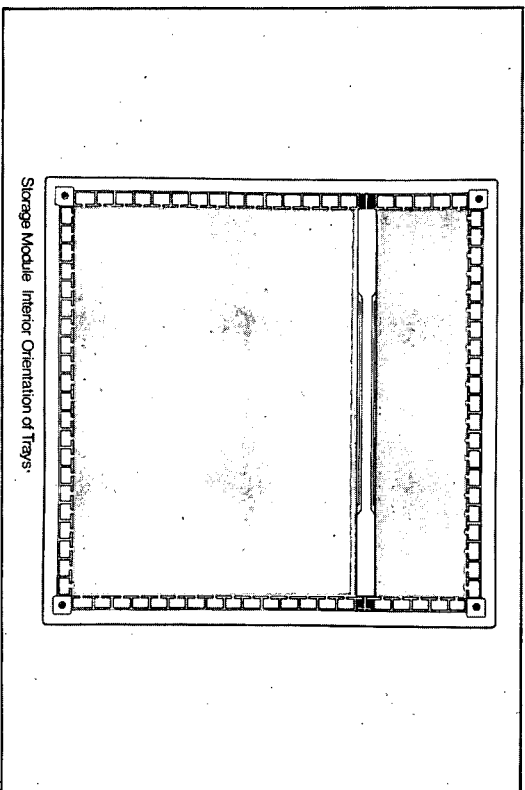
As illustrated in Figure N22, the crewmen are able to remove individual trays or a group of trays locked together and carry them to the required area of the spacecraft. A detail of the locking mechanism is demonstrated in Figure N23. The trays slide in between two extrusions with a slight resistance caused by shock mounted foam pads on the two outer edges of the trays. To lock the tray in place, a lever located on the front hand grip is flipped 180° directing rods into a slotted portion of the extrusion to the left and right of the tray.

The locking action can be accomplished with the thumb while holding on to the tray handle.

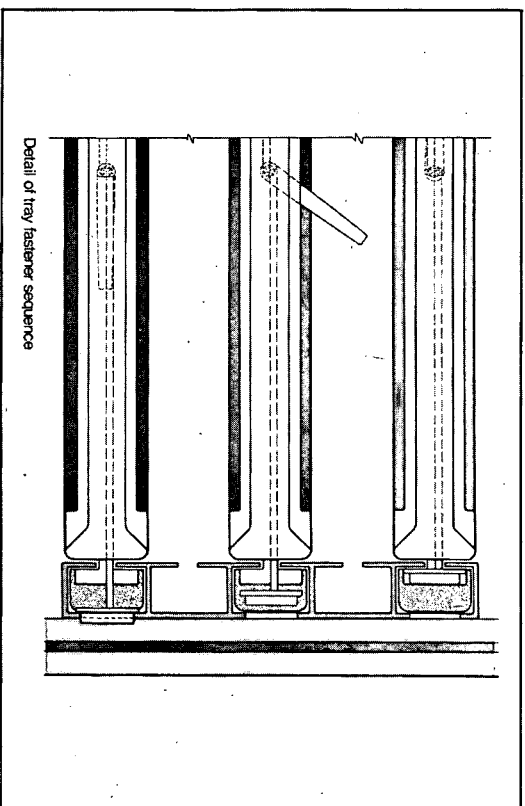
d) Component Restraints

The tray orientation will be established by the character of the article stowed and the direction in which it will best accept the launch loads.

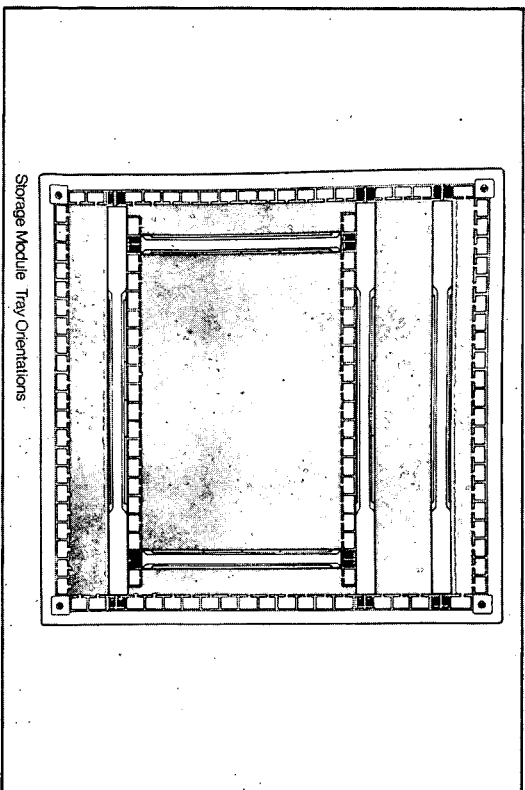
Figures N24-N28 represent several concepts for restraining components, equipment or experiments on the trays. Figure N24 is an extrusion adaption insert which would be used to form tray groupings as in Figure N22. The extrusion on these trays would have the identical tray restraining capabilities as those mounted on the interior of the locker module.



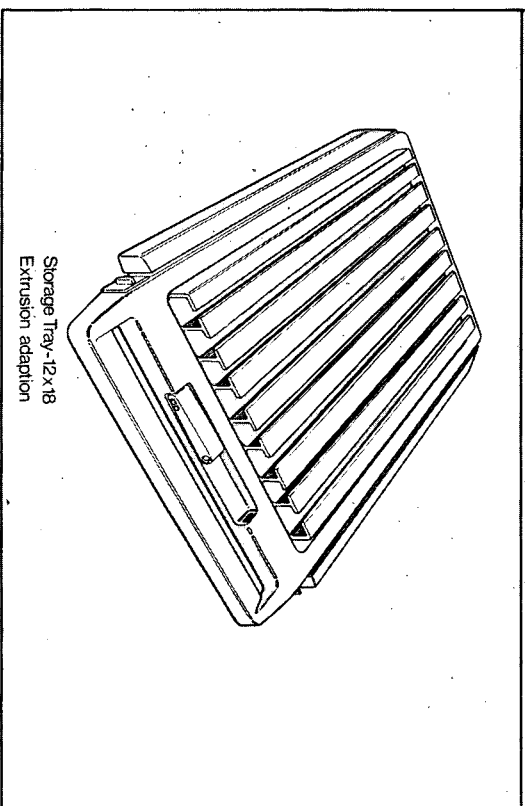
N21 - Single Tray Mounted in Storage Locker



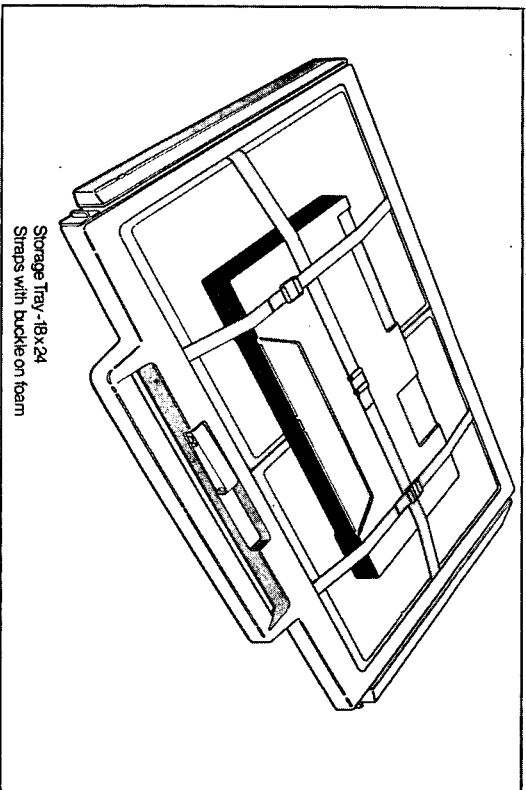
N23 - Sequential Detail of Fastening Tray to Locker



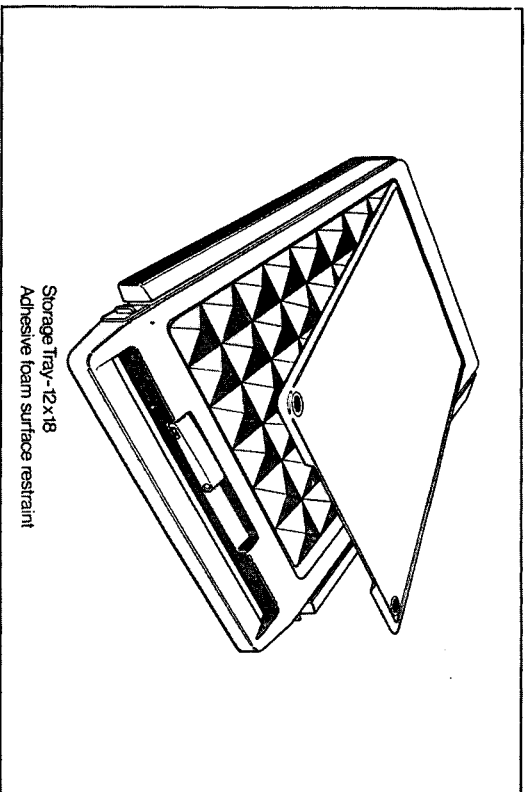
N22 - Possible Storage Tray Orientations



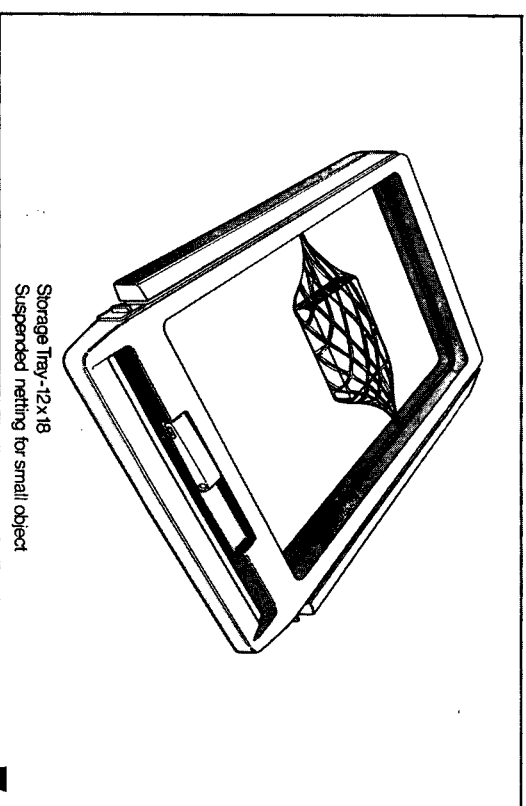
N24 - Extrusion Adapter to Reorient Trays



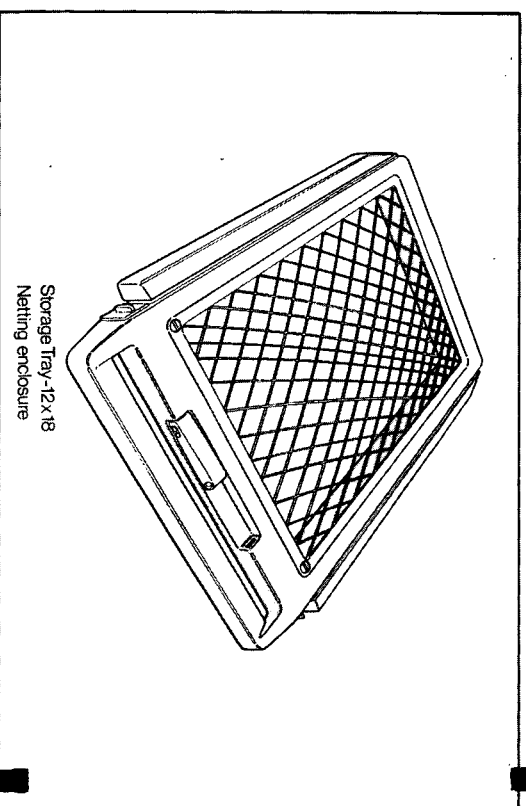
N25 - Strap and Buckle Restraint for Storage Tray



N26 - Adhesive Foam Surface Restraint for Storage Tray



N27 - Twisted Netting Restraint for Storage Tray Restraint



N28 - Netting Enclosure for Storage Tray Restraint

Figure N25 is a general purpose restraint, an insert used mainly for larger objects sealed in a container. Straps in two directions would prevent the expected vibrations from shifting the object free.

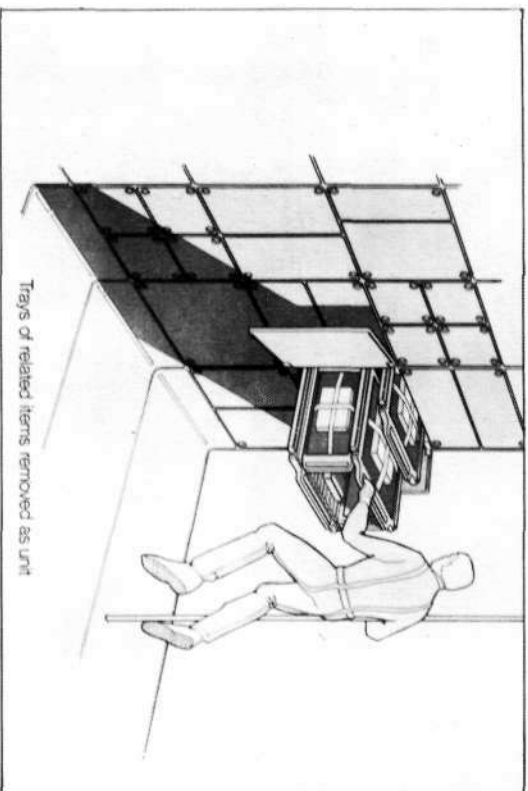
For smaller articles, Figure N26 has an insert made of wedge-shaped foamed surface. The unit has a cover enclosing the entire area. Small objects are placed on an adhesive coated surface which prevents dispersion of articles when the lid is opened in O-G.

An elasticized pouch suspends between the sides of the tray in Figure N27 enabling some components, usually of medium size, to hang completely free. The netted pouch is twisted and hooked on couplers at desired intervals for proper restraint. Space between nets and between trays should be adjusted to prevent interference with each other, especially during extreme launch vibrations.

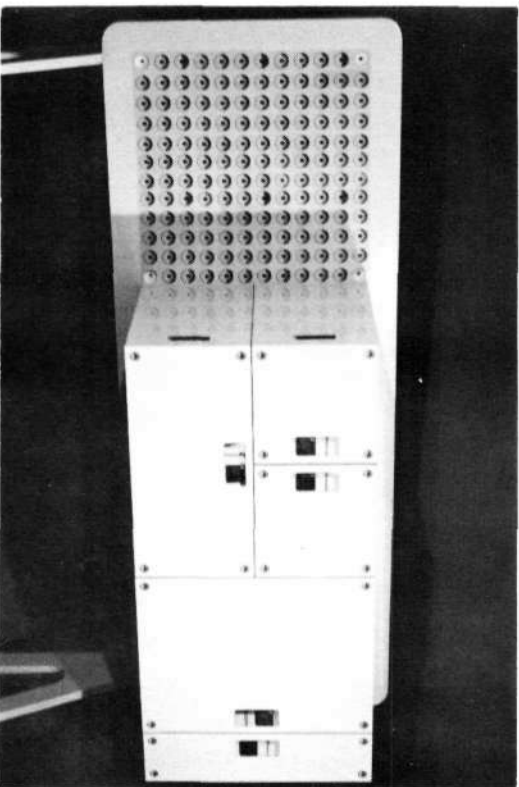
## RESULTS

### FIGURES N30-N37

A demonstration model of the storage locker system was constructed to better illustrate the concept and evaluate the practicality of the principles involved, as illustrated in Figures N30-N37.



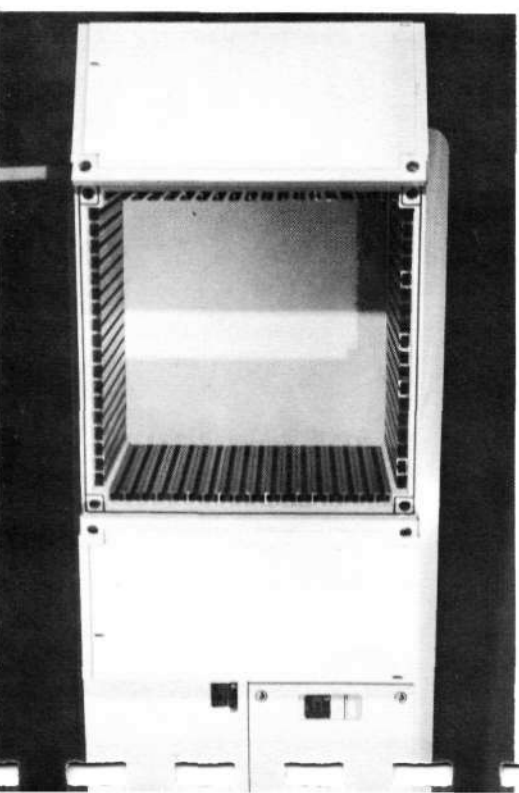
N30 - Drawing of Single Tray and Multiple Tray Groupings Being Removed



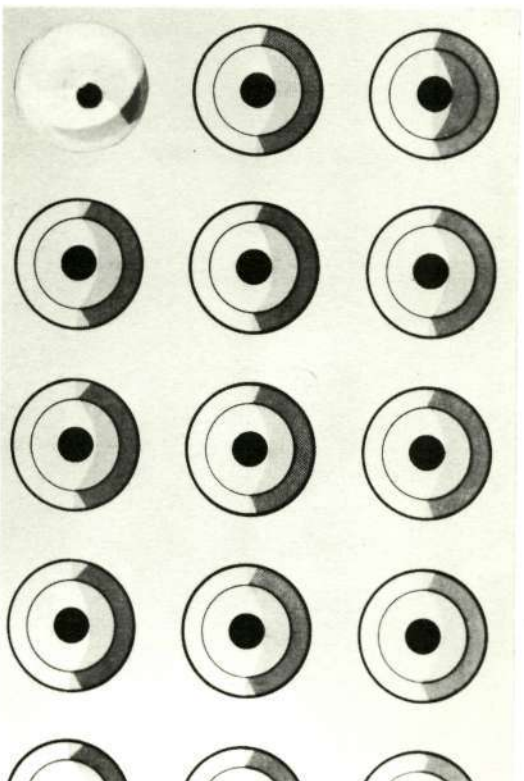
N31 - Storage Locker Demonstration Model Illustrating Support Wall and Module Breakup



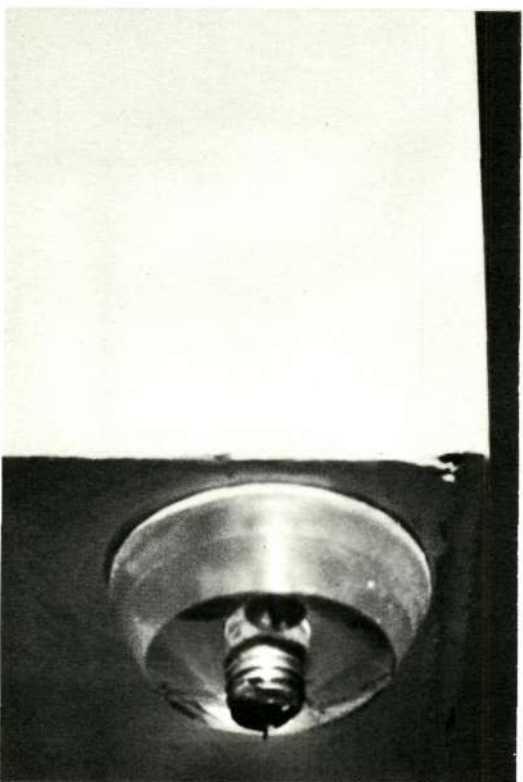
N32 - Storage Module Affixed to Wall by Turning Fasteners from Front Surface



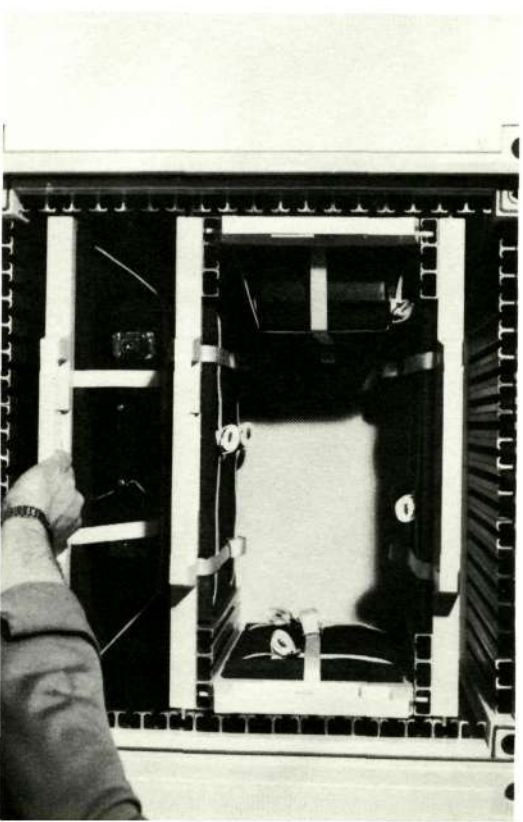
N33 - Inside View of 24" X 24" X 18" Storage Module in Place



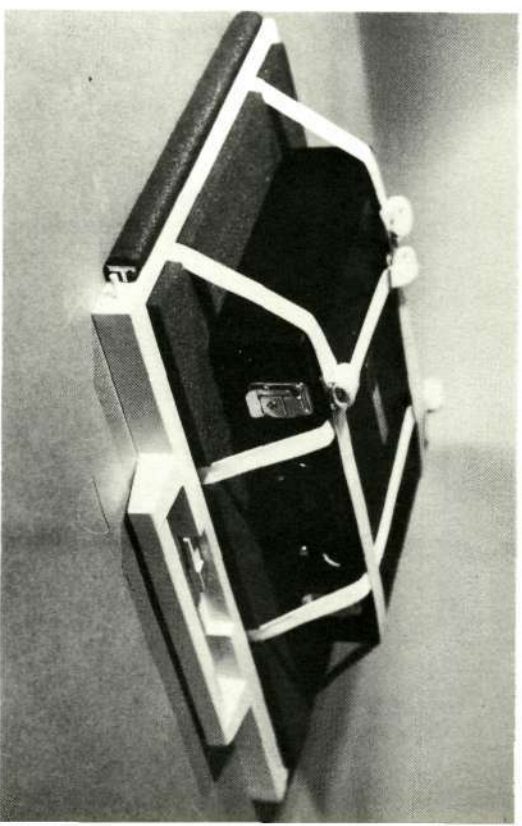
N34 - Detail of Support Wall Recesses



N35 - Detail of Back Surface of Storage Locker



N36 - Interior View of Storage Locker with Single and Multiple Tray Groupings



N37 - Storage Locker Tray Details